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SIR. LINDSAY WOOD, BART.,

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS 1896-1897 AND 1902-1903.

Transactions of The Institution of Mining Engineers

Edited by the Secretary

VOL. XXIV.

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WOODWORTH, BENJAMIN.
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WRIGHTSON, SIR THOMAS, Bart., Stockton-upon-Tees
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WROE, JONATHAN, Wharncliffe Silkstone Colliery, Barnsley.
WYPER, JAMES, Townlands Colliery, Hamilton, N.B.

YEOMAN, THOMAS P., Government Collieries, Warora, Central Provinces, India.
YONCKRA, K., Hokkaido Colliery and Railway Company, Sapporo, Hokkaido, Japan.
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YOUNGER, JOHN WISHART, The Poplars, North Biddick, Washington Station, Co. Durham.

Associate Members.

Assoc.M.Inst.M.E.

Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

* Deceased.

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Wrightson, Wilfrid Ingram, Neasham Hall, Darlington.

Associates.

Assoc. Inst. M. E.

Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

* Deceased.

Adams, Charles, Whitfield Collieries, Norton-in-the-Moors, Stoke-upon-Trent.
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ARCHER, MATTHEW WILLIAM, High Priestfield, Lintz Green, Co. Durham.
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ARMSTRONG, WILLIAM P., Bewicke Main, Birtley, R.S.O., Co. Durham.

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BELL, W. R., Wearmouth Colliery, Sunderland.
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Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper, etc.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas-producers, and gaseous fuel and illuminants.
Gas, oil and petroleum engines.
Geology and mineralogy.
Gold-recovery plant and processes.
Graphite: its mining and treatment.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Light railways.
Lubricating value of grease and oils.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mineral resources of colonies.
Mining and uses of arsenic, asbestos, bauxite, mercury, etc.
Natural gas, conveyance and uses.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Preservation of timber.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rectification of mineral oils.
Rock-drills.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Sleepers of cast-iron, steel and wood.
Smelting.
Spontaneous ignition of coal and coal-seams.
Stamp-milling.
Steam-condensation arrangements.
Steam-power plants.
Submarine coal-mining.
Subsidences caused by mining-operations.
Sulphur-mining.
Surface-arrangements of mines.
Surveying.
Tin-mining.
Transport on roads.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Ventilation of mines.
Water as a motive-power in mines.
Water-tube boilers.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

GOD SAVE THE KING.

H. M.

KING EDWARD VII.

AND H. M.

QUEEN ALEXANDRA,

OF THE UNITED KINGDOM OF

GREAT BRITAIN AND IRELAND AND THE

DOMINIONS THERETO BELONGING.

CORONATION, AUGUST 9TH, 1902.

To the King's Most Excellent Majesty.

The Humble and Dutiful Address of

The Institution of Mining Engineers.

Most Gracious Sovereign,

The Institution of Mining Engineers beg leave humbly to approach Your Majesty's Throne on the Occasion of the August Ceremony of Your Majesty's Coronation, and to tender its Sincere and Heartfelt Congratulations on the Auspicious Event.

We desire to present our Ardent and Sincere Wishes for Your Majesty's Health and Welfare, and Fervently Pray that Your Majesty may wear with Glory and Happiness the Crown transmitted to Your Majesty and long continue to Reign over a Happy, Prosperous and United People.

Signed by order of the Council.

M. WALTON BROWN, Secretary.

June 21st, 1902.

HOME OFFICE, WHITEHALL,

4th September, 1902.

SIR,

I am commanded by the King to convey to you hereby His Majesty's thanks for the Loyal and Dutiful Address of The Institution of Mining Engineers, on the occasion of Their Majesties' Coronation.

I am, Sir,

Your obedient Servant,

A. AKERS DOUGLAS.

The Secretary to The Institution of Mining Engineers,
Newcastle-upon-Tyne.

4 0 0

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 2ND, 1902.

MR. J. G. WEEKS, RETIRING PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 19th and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1902-1903.

The CHAIRMAN (Mr. J. G. Weeks) appointed Messrs. L. Austin, J. Kirsopp, jun., Thomas Lowdon, N. B. Ridley, J. Southern and W. B. Wilson, jun., as scrutineers of the balloting-papers for the election of officers for the year 1902-1903. The scrutineers afterwards reported the result of the ballot, as follows:—

PRESIDENT:
SIR LINDSAY WOOD, Bart.

VICE-PRESIDENTS:

Mr. R. DONALD BAIN.
Mr. T. W. BENSON.
Mr. C. BERKLEY.
Mr. W. C. BLACKETT.
Mr. T. E. FORSTER.
Mr. WILLIAM LOGAN.

COUNCILLORS:

Mr. R. S. ANDERSON.	Mr. T. Y. GREENER.	Mr. C. C. LEACH.
Mr. SIDNEY BATES.	Mr. J. K. GUTHRIE.	Mr. JOHN SHIEL.
Mr. G. F. BELL.	Mr. T. E. JOBLING.	Mr. F. R. SIMPSON.
Mr. C. S. CARNES.	Mr. A. C. KAYLL.	Mr. JOHN SIMPSON.
Mr. B. DODD.	Mr. P. KIRKUP.	Mr. E. O. SOUTHERN.
Mr. M. H. DOUGLAS.	Mr. H. LAWRENCE.	Mr. R. L. WEEKS.

Mr. JOHN SIMPSON moved, and the RETIRING PRESIDENT seconded, a vote of thanks to the scrutineers for their services, and it was cordially approved.

Mr. THOMAS DOUGLAS moved a vote of thanks to the Retiring President, Vice-Presidents and Councillors, and to the representatives of the Institute on the Council of The Institution of Mining Engineers, for their services during the past year. Their President (Mr. J. G. Weeks) had devoted a very large amount of time and attention to the affairs of the Institute, which had progressed materially during his term of office.

Mr. W. C. BLACKETT, in seconding the vote of thanks, remarked that the President had carried out his duties to the entire satisfaction of the members.

The vote of thanks was cordially approved.

The RETIRING PRESIDENT (Mr. J. G. Weeks), in acknowledging the vote of thanks on his own behalf, and also on behalf of the members of the Council and of their representatives on the Council of the Institution of Mining Engineers, thanked the members for the kind manner in which they had appreciated what had been done during their term of office. Personally, he was very grateful for the honour which they had conferred upon him in electing him as their President; and it was interesting to note that four Presidents had been connected with the Bedlington collieries: namely, the late Mr. Nicholas Wood, Mr. John Daglish, Mr. Thomas Douglas and himself.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1901-1902.

The North of England Institute of Mining and Mechanical Engineers was initiated on July 3rd, 1852, "at a meeting of colliery-owners, viewers and others interested in the coal-trade, ... for the purpose of forming a society, to meet at fixed periods and discuss the means for the ventilation of mines, for the prevention of accidents, and for general purposes connected with the winning and working of collieries;" under the title of "The North of England Society, for the Prevention of Accidents, and for other Purposes connected with Mining." Of the 44 gentlemen attending that meeting, 7 survive, and 4 of them (Messrs. Charles William Anderson, Cuthbert Berkley, John Daglish and Thomas Douglas) are still members of the Institute.

The celebration of the Jubilee of the Institute will be held on September 16th next, and, at the invitation of the Council, The Institution of Mining Engineers will conjointly hold their annual meeting.

The following table shews the progress of the membership in successive decades:—

Year ending August 1st.	1862.	1872.	1882.	1892.	1901.	1902.
Honorary Members ...	16	24	22	24	28	25
Members	295	618	669	545	880	893
Associate Members ...	—	—	—	35	122	109
Associates	—	—	—	34	116	122
Students	—	64	115	35	57	66
Subscribers	15	14	13	18	23	23
Totals ...	326	720	819	691	1,226	1,238

Although 93 gentlemen have been elected during the past year, there has only been a slight increase in membership, due to the exceptional number of members who have died, and also to the names of a considerable number of members, etc., having been removed from the register by the Council.

The Library has been maintained in an efficient condition during the past year, and the books are now more readily accessible by reference to the card-index. The additions by donation, exchange and purchase, include 314 bound volumes, 151 pamphlets, reports, etc., and the Library now contains about 8,943 volumes and 2,640 pamphlets.

Members would render valuable service to the profession by the donation of books, reports, plans, etc., to the Library, where they would be available for reference.

The Lecture-theatre is being altered and decorated, and will be ready for use during the Jubilee meeting.

The three years' course of lectures for colliery-engineers, engine-wrights, apprentice mechanics, etc., at the Durham College of Science has proved very successful. The lectures are delivered on Saturday afternoons, and the next course will commence in October next. The entire course is as follows:—

1902-1903. Michaelmas Term, (1) Transmission of Power, and (2) Pumping and Ventilation. Epiphany Term, (3) Metallurgy of Iron and Steel, and (4) Mining Machinery (chiefly used underground).

1903-1904. Michaelmas Term, (5) Mensuration, and (6) Chemistry of Fuel. Epiphany Term, (7) Strength of Materials, and (8) Experimental Mechanics.

1904-1905. Michaelmas Term, (9) Theoretical Electricity, and (10) Electrical Engineering Epiphany Term, (11) Steam-engines and Boilers, and (12) Haulage and Winding.

Several owners of collieries have paid the fees (£1 10s. per annum) and railway-expenses of pupils attending the classes from their collieries. During the past year, the lectures of Michaelmas term on Theoretical Electricity and Electrical Engineering were attended by 111 and 110 students respectively: 77 sat for examination and 67 passed. During Epiphany term, the lectures on the Steam-engine and Haulage and Winding were attended by 91 students, of whom 68 sat for examination and 55 passed. Prizes have been awarded to Messrs. James Wray and Arthur Hepburn. Certificates have been awarded to the following students who have completed a three years' course:— Messrs. William Alderson, William Pinkney Armstrong, Alfred Clark, John George Crowder, William Cummings, Thomas Henderson, Arthur Hepburn, Ernest Horler, George William Maddison, James Oswald, William Wainwright and James Wray. Mr. James Wray has received the first prize during each year of his course.

General and Subject-matter Indices to volumes i. to xxxviii. of the *Transactions* have been published, and will facilitate references to papers.

A *Subject-matter Index of Mining, Mechanical and Metallurgical Literature for the Year 1900,* has been issued to the

members, and will afford access to a large mass of technical literature.

By a mutually advantageous arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, the members of either institution are permitted to refer to the books in the Library of the other. The members are also accorded free access to the Museum of the Natural History Society of Newcastle-upon-Tyne.

Mr. John Daglish continues to represent the Institute as a governor of the Durham College of Science, which was jointly founded in 1871 by the University of Durham and the North of England Institute of Mining and Mechanical Engineers. Mr. T. E. Forster represents the Institute on the Council of the Durham College of Science, and the President (Mr. John G. Weeks) is also an *ex-officio* member.

Mr. J. H. Merivale will again represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science, to be held in Belfast in September, 1902. Prof. H. Louis is the representative of the Institute on the Science & Art and Scholarships Committees of the Northumberland County Council. Mr. W. Cochrane represents the Institute upon the board of directors of The Institute and Coal-trade Chambers Company, Limited.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows:—Messrs. Henry Armstrong, R. Donald Bain, John Batey, W. C. Blackett, Bennett H. Brough, T. Forster Brown, A. G. Charleton, William Cochrane, Thomas Douglas, William Galloway, John Gerrard, Reginald Guthrie, John L. Hedley, A. C. Kayll, Henry Lawrence, C. C. Leach, Henry Louis, J. H. Merivale, John Morison, Henry Palmer, Frank R. Simpson, A. L. Steavenson and John G. Weeks.

The following additional exchanges of *Transactions* have been arranged during the year:—

Le Mois Scientifique et Industriel, Paris.
American Philosophical Society.
Société d'Encouragement pour l'Industrie Nationale.
The Institution of Electrical Engineers.

Prizes of books have been awarded to the writers of the following papers, communicated to the members during the year 1900-1901:—

"The Solvent Action of Pyridine on Certain Coals." By Mr. T. Baker, B.Sc.
"Endless-rope Haulage at Axwell Park Colliery." By Mr. R. W. Glass, Stud.I.M.E.
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse, M.I.M.E.
"Dry and Wet Treatment of Copper-ores." By Capt. C. C. Longridge, M.I.M.E.
"The Employment of Iron Bars at the No. 6 Pit, Lens Colliery." By Mr. E. Reumaux.
"A Method of Boring Deposits out of Rising-main Pipes in Shafts." By Mr. Hugh Ross, M.I.M.E.
"A Flash of Lightning at the Lambton Colliery, D and Lady Ann Pits, on October 2nd, 1900." By Mr. Jacob Sharp, M.I.M.E.
"Safety-lamp Cabin at Heworth Colliery." By Mr. Thomas V. Simpson, Stud.I.M.E.
"Sinking through Swamp, Clay and Sand." By Mr. William Tattley, M.I.M.E.
"Endless-rope Haulage at Pelton Colliery." By Mr. Norman M. Thornton, Stud.I.M.E.

The papers printed in the *Transactions* during the year are as follows:—

"A Method of Socketing a Winding-rope, and its Attachment to a Cage without the Use of Ordinary Chains." By Mr. W. C. Blackett, M.I.M.E.
"Mechanical Undercutting in Cape Colony." By Mr. John Colley, M.I.M.E.
"Electric Pumping-plant at South Durham Collieries." By Mr. Fenwick Darling, M.I.M.E.
"Memoir of the late George Baker Forster." By Mr. R. H. Forster.
"Memoir of the late George Clementson Greenwell." By Mr. G. C. Greenwell, M.I.M.E.
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse, M.I.M.E.
"Apparatus for closing the Top of the Upcast-shaft at Woodhorn Colliery." By Mr. C. Liddell, Stud.I.M.E.
"Note on a Mineral Vein in Wearmouth Colliery." By Prof. Henry Louis, M.I.M.E.
"Standardization of Surveyors' Chains." By Prof. Henry Louis, M.I.M.E.
"Report of the Delegate to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Glasgow, 1901. By Mr. John H. Merivale, M.I.M.E.
"A Visit to the Simplon Tunnel: the Works and Workmen." By Dr. Thomas Oliver.
"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson, M.I.M.E.
"Auriferous Gravels and Hydraulic Mining." By Mr. William S. Welton, M.I.M.E.
"Tapping Drowned Workings at Wheatley Hill Colliery." By Mr. W. B. Wilson, Jun., M.I.M.E.

Mr. James Stirling, government geologist and mining representative of Victoria, delivered an interesting lecture on "Mines and Mining in Victoria," illustrated by lantern-slides.

The award of the Greenwell medals will be made for approved papers communicated during the past year "recording the results of experience, and the deductions and practical suggestions of the writers for the avoidance of accidents."

As no papers have been received in competition for the prize offered by Mr. Clarence R. Claghorn for an approved essay on "The Action, Influence and Control of the Roof in Longwall Working," the Council will select another subject for papers in competition for this prize.

Excursions have been made to South Durham, Washington and Woodhorn collieries, and to the Parson Byres quarries, and the thanks of the members have been accorded to the owners of these collieries and works.

Members are desired to send copies of any unpublished sections of strata in the counties of Northumberland and Durham, in order that they may be incorporated in a supplementary volume to *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings.*

A committee has been appointed to investigate and report upon labour-saving machines and tools used in cutting and boring coal and rock.

The members are to be congratulated on the success that has attended the formation of The Institution of Mining Engineers, which has now completed its thirteenth year. Meetings have been held during the past year in the Glasgow district in September, 1901, and in London in May, 1902.

The CHAIRMAN (Mr. J. G. Weeks), in moving the adoption of the report of the Council, remarked that the number of papers read during the year was very satisfactory, the attendance at the meetings had been good, and altogether the members had got through a considerable amount of work.

Mr. THOMAS DOUGLAS seconded the resolution, which was unanimously agreed to.

The Report of the Finance Committee was read as follows:—

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1902.

The total receipts during that period were £2,813 2s. 6d. Of this amount, £24 18s. 0d. was paid as balance of life-composition in lieu of annual subscriptions; £102 8s. represent subscriptions paid in advance, and £10 has been received from Mr. Clarence R. Claghorn as a prize to be offered for a paper; leaving £2,675 16s. 6d. as the ordinary income of the year, as compared with £2,582 11s. 7d. in the previous year.

The expenditure amounted to £2,443 9s. 4d. as compared with £2,115 10s. 10d., the ordinary expenditure for last year. This increase is principally due to expenditure incurred in connection with the publication of the *General and Subject-matter Indices to the Transactions* and the *Subject-matter Index of Mining, Mechanical and Metallurgical Literature for the Year 1900*, and the additional sum paid to The Institution of Mining Engineers on the increased membership. Deducting the total expenditure from the income for the year, leaves a balance of £369 13s. 2d.; and this added to the sum of £637 13s. 10d. brought from the previous year, gives a credit-balance of £1,007 7s. 0d.

During the year £180 10s. have been written off the amount of subscriptions and arrears. The amount of subscriptions for the year 1901-1902 still unpaid is £271 19s. and for previous years £47 4s.

The cost of the alterations to the Lecture-theatre, ordered by the Council, will come into the accounts for the year 1902-1903. There will also be in that year, considerable expenditure in connection with the Jubilee of the Institute, but the Committee hope to be able to provide the necessary funds out of the balance in hand and the surplus income for the coming year.

THOMAS DOUGLAS.

August 2nd, 1902.

GENERAL STATEMENT, JUNE 30TH, 1902.

LIABILITIES.

	£	s.	d.	£	s.	d.
Subscriptions paid in advance during the current year	102	8	0			
Ditto. in the previous year	4	4	0			
	106	12	0			
The Institution of Mining Engineers ...	9	10	0			
Printing and Stationery	120	0	0			
				236	2	0
George Clementson Greenwell Prize Fund				100	0	0
Mr. Clarence R. Claghorn: Prize for Essay				10	0	0
Capital				12,073	1	2
				£12,419	3	2

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other Publications as valued by your Officials.

JOHN G. BENSON AND SON,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 2nd, 1902.

ASSETS.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	949	17	6			
" in Treasurer's hands	56	8	6			
Author's Excerpts	1	1	0			
				1,007	7	0
Arrears of Subscription				319	3	0
179 Shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100	0	0			
Investment with the Institute and Coal-trade Chambers Company, Limited (Mortgage)...	1,400	0	0			
				5,500	0	0
(Of the above amount, £1,013 14s. is due to Life Subscriptions Account.)						
Value of *Transactions* and other Publications, as per Stock Account				442	13	2
Books, Pictures, Maps, Furniture and Fittings				5,150	0	0
				£12,419	3	2

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

FOR THE YEAR ENDING

		£ s. d.	£ s. d
June 30th, 1901.			
To Balance at Bankers		593 6 10	
" " in Treasurer's hands		44 7 0	
			637 13 10
June 30th, 1902.			
To Dividend of 7½ per cent. on 179 Shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1902 ...		268 10 0	
" Interest on Mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited		49 0 0	
			317 10 0
To Sale of *Transactions*			77 0 6
To SUBSCRIPTIONS FOR 1901-1902 AS FOLLOWS:—			
706 Members	@ £2 2s.	1,482 12 0	
87 Associate Members	@ £2 2s.	182 14 0	
93 Associates	@ £1 5s.	116 5 0	
47 Students	@ £1 5s.	58 15 0	
58 New Members	@ £2 2s.	121 16 0	
2 New Members (not yet elected) ...	@ £2 2s.	4 4 0	
7 New Associate Members	@ £2 2s.	14 14 0	
13 New Associates	@ £1 5s.	16 5 0	
20 New Students	@ £1 5s.	25 0 0	
		2,022 5 0	
20 Subscribing Firms		88 4 0	
		2,110 9 0	
To LIFE COMPOSITION:—			
1 New Member		24 18 0	
		2,135 7 0	
Less—Subscriptions for current year paid in advance at the end of last year...		100 14 0	
		2,034 13 0	
Add—Arrears received		225 11 0	
		2,260 4 0	
Add—Subscriptions paid in advance during the current year		102 8 0	
			2,362 12 0
To Technical Index			46 0 0
To Mr. C. R. Claghorn for Prize			10 0 0
			£3,450 16 4

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.

JUNE 30TH, 1902.

June 30th, 1902.		£ s. d.	£ s. d.
By Annual Report ...		31 17 6	
" Banker's Charges ...		21 4 0	
" British Association for the Advancement of Science: Expenses of Delegate ...		9 0 0	
" Circulars, etc. ...		50 0 1	
" Cleaning Wood Memorial Hall, Offices, etc. ...		29 7 5	
" Electric Light and Gas ...		31 17 0	
" Expenses of General Meetings ...		6 15 6	
" Fire Insurance ...		12 4 3	
" Fuel ...		16 9 5	
" Furniture and Repairs ...		62 4 6	
" Illustrations ...		6 17 4	
" Incidental Expenses ...		8 17 0	
" Index to *Transactions* ...		100 0 0	
" Library—Books ...	£45 17 4		
" " Binding ...	43 7 11		
		89 5 3	
" Petty Cash ...		8 19 9	
" Postages—Circulars ...	£39 9 1		
" " Correspondence ...	21 11 2		
" " Publications ...	45 6 10		
		106 7 1	
" Prizes for Papers ...		24 13 9	
" Rates and Taxes ...		6 4 7	
" Rent of Offices ...		24 9 2	
" Reporting of General Meetings ...		13 2 6	
" Salaries, Wages, Auditing, etc. ...		471 13 7	
" Stationery, etc. ...		27 14 11	
" Technical Index ...		3 17 8	
" Telephone Rent ...		2 17 0	
" Travelling Expenses ...		2 19 0	
" Water Rate...		5 15 8	
" Wood Memorial Hall: Alterations ...		49 13 0	
			1,224 6 6
By The Institution of Mining Engineers ...		1,224 7 4	
Less—Amounts paid by Authors for Excerpts ...		5 4 6	
			1,219 2 10
			2,443 9 4
By Balance at Bankers ...		949 17 6	
" " in Treasurer's hands ...		56 8 6	
" Outstanding Amounts due for Authors' Excerpts ...		1 1 0	
			1,007 7 0
			£3,450 16 4

We, having examined the above account with the books and vouchers relating thereto, certify that, in our opinion, it is correct.

JOHN G. BENSON AND SON,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 2nd, 1902.

Dr.		The Treasurer in Account					
		£	s.	d.	£	s.	d.
To 880 Members.							
49 of whom have paid Life Compositions.							
831							
1 Member paid Life Composition					24	18	0
830							
4 not included in printed list.							
834	@ £2 2s.				1,751	8	0
To 122 Associate Members,							
8 of whom have paid Life Compositions.							
114	@ £2 2s.				239	8	0
To 116 Associates,							
5 of whom have paid as New Members.							
111 Associates	@ £1 5s.				138	15	0
To 57 Students							
2 of whom have paid as New Members.							
55							
1 of whom has paid Life Composition.							
54 Students	@ £1 5s.				67	10	0
To 23 Subscribing Firms					96	12	0
To 58 New Members	@ £2 2s.				121	16	0
To 2 New Members, not yet elected,	@ £2 2s.				4	4	0
60							
To 7 New Associate Members	@ £2 2s.				14	14	0
To 13 New Associates	@ £1 5s.				16	5	0
To 20 New Students	@ £1 5s.				25	0	0
					2,500	10	0
To Arrears, as per Balance Sheet 1900-1901		297	0	0			
Add—Arrears considered irrecoverable, but since paid...		63	1	0			
					360	1	0
					2,860	11	0
To Subscriptions paid in advance					102	8	0
					£2,962	19	0

WITH SUBSCRIPTIONS, 1901-1902. CR.

		PAID. £ s. d.	UNPAID. £ s. d.	STRUCK OFF LIST. £ s. d.
By 706 Members, paid	@ £2 2s.	1,482 12 0	......	......
By 96 " unpaid ...	@ £2 2s.	......	201 12 0	......
By 8 " dead	@ £2 2s.	......	......	16 16 0
By 24 " struck off list	@ £2 2s.	......	......	50 8 0
834				
By 1 Member, paid Life Composition		24 18 0	......	.....
By 87 Associate Members, paid	@ £2 2s.	182 14 0	......	......
By 17 " " unpaid	@ £2 2s.	......	35 14 0	.....
By 1 " " dead	@ £2 2s.	......	......	2 2 0
By 9 " " struck off list ...		......	......	18 18 0
114				
By 93 Associates, paid	@ £1 5s.	116 5 0	......	......
By 15 " unpaid ...	@ £1 5s.	......	18 15 0	......
By 3 " struck off list	@ £1 5s.	......	......	3 15 0
111				
By 47 Students, paid	@ £1 5s.	58 15 0	......	......
By 6 " unpaid ...	@ £1 5s.	......	7 10 0	......
By 1 " struck off list	@ £1 5s.	......	.....	1 5 0
54				
By 20 Subscribing Firms, paid		88 4 0	......	......
By 3 " " unpaid		......	8 8 0	......
23				
By 58 New Members, paid ...	@ £2 2s.	121 16 0	......	......
By 2 New Members, not yet elected, paid	@ £2 2s.	4 4 0	......	......
60				
By 7 New Associate Members, paid	@ £2 2s.	14 14 0	......	......
By 13 New Associates, paid ...	@ £1 5s.	16 5 0	......	......
By 20 New Students, paid ...	@ £1 5s.	25 0 0	......	......
		2,135 7 0	271 19 0	93 4 0
By Arrears		225 11 0	47 4 0	87 6 0
		2,360 18 0		
By Subscriptions paid in advance		102 8 0	......	......
		2,463 6 0	319 3 0	180 10 0
				319 3 0
				2,463 6 0
				£2,962 19 0

The CHAIRMAN (Mr. J. G. Weeks), in moving the adoption of the report of the Finance Committee, said it was satisfactory to know that there was a considerable credit-balance. The alterations to the Lecture-theatre would cost about £1,000, and when these were completed he thought that the comfort and convenience of the members would be materially increased. The architect had promised that the alterations should be completed in time for the Jubilee Meeting in September next.

Mr. THOMAS DOUGLAS seconded the resolution, which was unanimously agreed to.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS.

Mr. THOMAS DOUGLAS moved, and Mr. W. C. BLACKETT seconded a resolution, that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1902-1903:—

Mr. WILLIAM ARMSTRONG.	Mr. T. E. FORSTER.	Mr. JOHN MORISON.
Mr. JOHN BATEY.	Mr. WILLIAM GALLOWAY.	Mr. M. W. PARRINGTON.
Sir LOWTHIAN BELL, Bart.	Mr. JOHN GERRARD.	Prof. R. A. S. REDMAYNE.
Mr. T. W. BENSON.	Mr. REGINALD GUTHRIE.	Mr. A. R. SAWYER.
Mr. BENNETT H. BROUGH.	Mr. PHILIP KIRKUP.	Mr. J. B. SIMPSON.
Mr. A. G. CHARLETON.	Mr. C. C. LEACH.	Mr. JOHN G. WEEKS.
Mr. JOHN DAGLISH.	Prof. HENRY LOUIS.	Sir LINDSAY WOOD, Bart.
Sir DAVID DALE, Bart.	Mr. GEORGE MAY.	Mr. W. O. WOOD.

The resolution was agreed to.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

MR. ARTHUR ANDREWS, Electrical Engineer, 20, Carlyon Street, Sunderland.

MR. JOHN FRANK BLEDSOE, Mining Engineer, 309-310, Washington Block, Seattle, Washington, United States of America.

MR. THOMAS WILLIAM DAVIES, Mining Engineer, Vereeniging Estates, Vereeniging, Transvaal.

MR. GEORGE ELTRINGHAM, Colliery Manager, Eltringham Colliery, Ovingham-upon-Tyne, Northumberland.

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MR. GUSTAVE GILLMAN, Civil Engineer, Aguilas, Provincia de Murcia, Spain.

MR. JOHN DAMPIER GREEN, Engineer, P.O. Box 340, Johannesburg, Transvaal.

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MR. EARLE W. JENKS TREVOR, Mining Engineer, 78, Palace Chambers, 9, Bridge Street, Westminster, London, S.W.

MR. ROBERT TURNBULL, Mechanical Engineer, Usworth Colliery, Washington, R.S.O., County Durham.

MR. MICHAEL WATSON, Mechanical Engineer, 4, St. Nicholas Buildings, Newcastle-upon-Tyne.

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MR. JOHN CUMMINGS, Colliery Under-manager, Rowlands Gill Colliery, Newcastle-upon-Tyne.

MR. THOMAS FORD, Overman, Washington, R.S.O., Co. Durham.

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STUDENTS—

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MR. GEORGE COOK, Mining Student, Binchester Hall, Bishop Auckland.

MR. BENJAMIN STARKS FIELD, Mining Engineering Apprentice, 8, Esplanade, Whitley, R.S.O., Northumberland.

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MR. GEORGE ADAMSON STRONG, Mining Student, Byron House, Ouston Chester-le-Street, County Durham.

MR. WILLIAM WILSON, Mining Student, Usworth Colliery, Washington, R.S.O., County Durham.

THE GASES ENCLOSED IN COAL.*

By Dr. BROOCKMANN.†

The first work on this subject was done by Prof. Ernst von Meyer‡ in 1870, his method being as follows:—

Pieces of coal of the size of a nut were boiled in a flask, filled with boiling (air-free) water, and closed with an indiarubber-stopper, through which a glass tube led the escaping gases, which were collected over boiling water. In order to obtain the gas in the pure state, it is necessary to keep the water boiling gently. When vigorous ebullition takes place, air diffuses into the flask, however good the indiarubber-stopper may be.

Prof. E. von Meyer obtained from British and Westphalian coals, heated to 100° Cent., from 4 to 238 cubic centimetres of gas per 100 grammes of coal. The gases were of variable composition: all contained nitrogen, oxygen, carbonic acid and marsh-gas; and coals from Zwickau gave off higher hydrocarbons in addition to the above-named gases.

In 1875, Mr. W. J. Thomas§ extracted the gases by heating to 100° Cent. and afterwards exhausting the gases by means of a Sprengel air-pump. He thus obtained from 30 to 600 cubic centimetres of gas per 100 grammes of dry South Wales coal, the gas having the same composition as that given by Prof. E. von Meyer. Some cannel coals and jet, however, gave only carbonic acid and nitrogen, others carbonic acid, nitrogen, marsh-gas and higher hydro-carbons. Mr. Thomas used indiarubber-tubes for connecting his apparatus.

* "Ueber die in Steinkohlen eingeschlossenen Gase," *Gluckaüf*, 1899, vol. xxxv., pages 269 to 274.

† Translated and somewhat condensed by Prof. Henry Louis.

‡ *Journal für Praktische Chemie*, new series, vol. iv., page 42; and vol. v., pages 144 and 407.

§ *Journal of the Chemical Society*, 1876, vol. xxx., page 144.

Prof. Jeller experimented on coals from Rossitz by the Meyer method, and obtained per 100 grammes of coal heated to 100° Cent.:—

	Gas. Cubic centimetres.	Carbonic Acid, CO_2. Per cent.	Marsh-gas, CH_4. Per cent.	Ethane, C_2H_6. Per cent.	Nitrogen, N_2. Per cent.
I. ...	54	56	3	16	25
II. ...	38	35	10	4	51
III. ...	60	36	25	7	32

The author investigated dust and coal from Rossitz, the coal, however, being old. He obtained somewhat different results from Prof. Jeller, and he is not quite certain whether higher hydrocarbons than ethane (C_2H_6) were not present. With this reservation, he found 50 cubic centimetres of gas containing 31 per cent. of carbonic acid, 30 per cent. of marsh-gas, 19 per cent. of ethane, and 20 per cent. of nitrogen.

Recently Dr. P. P. Bedson, of the Durham College of Science, Newcastle-upon-Tyne, has taken up the same subject.* He used about the same method as that employed by Mr. Thomas. The coals were heated in a closed vessel to different temperatures, the glass vessel being closed by a perforated indiarubber-stopper and connected with an air-pump to draw off the escaping gases. In addition to other coals, Dr. Bedson investigated the coal of the Hutton seam of the Ryhope colliery, Durham, the dust of which coal is known to be dangerous. He examined the fresh coal, coal subsequently pulverized, and also coal-dust. From 100 grammes of fresh coal he obtained 818 cubic centimetres of gas, which, however, only contained 17 per cent. of combustible gases. From the pulverized coal, which he heated to 184° Cent., he obtained a gas containing 27 per cent. of oxygen.

Dr. Bedson probably was not aware of the labours of the Austrian Commission, or he would have referred to them. He lays down as quite new the existence of two types of coals: (1) those which contain higher hydrocarbons, and are dangerous, and (2) those which contain no higher hydrocarbons, and form a less dangerous dust.

As already pointed out, all the chemists in question have used indiarubber. This is an almost indispensable material for the chemist, but, unfortunately, it is unsuitable in many cases, especially when working with pressures varying from the normal,

* *Trans. Inst. M.E.*, 1894, vol. vii., pages 27 to 53; and *Colliery Manager and Journal of Mining Engineering*, 1895, vol. xi., pages 30 to 32.

as in the instances above, in which there are marked differences of pressure in the different vessels, under which conditions indiarubber is as permeable to gases as a sieve is to water.

The author can refer to a mass of literature in support of this statement, which can also readily be proved by experiment. If this property of indiarubber be borne in mind, it is easy to understand how Prof. von Meyer obtained 238 cubic centimetres of gas, Mr. Thomas 600, and Dr. Bedson 818, as the maximum from 100 grammes of coal when heated to 100° Cent. All these three chemists have collected and investigated not the pure gases occluded in coals, but atmospheric air, from which the heated coal has absorbed a greater or lesser quantity of oxygen, and which was more or less contaminated with the occluded gases and the products of the heating of the coal. The latter point will be referred to again.

The author doubts the accuracy of the results obtained by these chemists, more particularly those of Dr. Bedson, so far as concerns Westphalian coals:—(1) He had long ago obtained some gas by boiling coal under water, but had contented himself with proving that such gases were combustible gases, the quantity being too small for analysis. (2) He had examined 30 to 40 pure blowers in Westphalian collieries, which gave over 99 per cent. of marsh-gas, the remainder being carbonic acid, but no trace of nitrogen or oxygen. As the occluded gases are indubitably the sources of the blowers, the latter would obviously have to contain nitrogen and oxygen if these were contained in the occluded gases. Blowers from other coal-fields have often been found to contain almost pure marsh-gas. (3) He had certainly found, now and then, traces of hydrocarbons or of hydrogen itself in the air of Westphalian collieries; but he had long ago come to the conclusion that both of these gases were not originally contained in the gases escaping from the coal, and that they had found their way into the return-airways owing to decomposition, heating, or accidental admixture.

In order to obtain gases as pure as possible from coal, he had arranged a Sprengel air-pump, on which a glass vessel was blown, to act as the receiver for the coals. By this arrangement all possibility of leakage in the apparatus was excluded. In order to remove as far as possible adhering air from the inner surface of the glass and from the coal, he had allowed his apparatus to

stand as long as three days, repeatedly renewing the vacuum; he had then heated the vessel containing the coal to 100° Cent. in a water-bath, drawn off the escaping gases, and collected them over mercury.

All who know how difficult it is to remove adhering air from solid bodies will understand the necessity for this precaution; it, nevertheless, involves a source of error, inasmuch as each renewal of the vacuum removes a certain amount of the gases escaping from the coal, namely, such as would escape at ordinary atmospheric temperature into a vacuum. This error will be greater in those coals which give off their enclosed gases readily than in others which hold them more firmly. It is impossible, therefore, in the Meyer method, or in any other, to determine the total quantity of the enclosed gases. For instance, in the author's method, only that portion is obtained which is able to escape from pieces of the dimensions employed *in vacuo* at a temperature of 100° Cent., minus that portion which escapes while the vacuum is being produced. The quantities of gas obtained by the author must therefore be looked upon as minima. They are, however, comparable with each other, because he always used fragments of the same size (2 to 4 millimetres in diameter). It is obvious that the larger the fragments the more gas will be retained in the coal, while it can escape the more readily the smaller the particles are.

Table I. shows the results of his investigations; and, for convenience, the coke and gas obtainable in each experiment are given, calculated upon the pure coal. The quantity of coal employed was always 100 grammes. It was always heated to 100° Cent. in the water-bath, and the gases removed until completely exhausted, which often took several days.

The Austrian Commission, and also Dr. Bedson, have attempted to draw various conclusions from the gases occluded in coal. They have attempted to explain explosions of coal-dust as follows:—Owing to the heat of a blown-out shot, the occluded gases are supposed to be evolved from the coal-dust thrown up by the shot, and this gas should form with air an explosive mixture which may be fired by the flame of the shot. This explosion would then induce a subsequent true coal-dust explosion. The gas is supposed to be especially dangerous when higher hydrocarbons are present in the occluded gases. These form an explosive mixture with air, and are, moreover, easily inflammable.

TABLE I.

	Westphalia.						England.	Saarbrücken.	Upper Silesia.		Obern-Kirchen.	
	I. Smithy Coal, President Pit, near Bochum.	II. Lean Coal, Gabe Gottes Seam, Stock and Scherenberg.	III. Coking Coal, No. 13 Seam, Hibernia.	IV. Gas Coal, No. 12 Seam, Rhein-Elbe.	V. Coking Coal, No. 8 Seam, Pluto.	VI. Cannel Coal, No. 7 Seam, Mathias Stinnes.	VII. Hutton Seam, Ryhope Colliery.	VIII. No. 3 Seam, Camphausen.	IX. Sattel Seam, Gräfin Laura.	X. ?	XI. Walder coal, Bückeburg.	XII. Lignite, Habichtswald.
Coke	77	80	74	60	74	46	63	60	63	62	80	56
Gas	23	20	26	40	26	54	37	40	37	38	20	44
Volume of gases, cubic centimetres	87	50	100	10	150	7	70	100	30	20	90	50
COMPOSITION OF THE GASES.												
Marsh-gas, CH_4	96	75	94	12	87	60	94	84	—	—	94	—
Carbonic acid, CO_2	2	22	6	21	13	40	3	16	60	32	3	91
Nitrogen, N_2...	2	3	—	67	—	—	—	—	30	61	3	—
Oxygen, O_2	—	—	—	—	—	—	—	—	5	3	—	—
Olefines, C_xH_y	—	—	—	—	—	—	3	—	—	—	—	—
Carbon monoxide, CO ...	—	—	—	—	—	—	—	—	5	4	—	9
Totals ...	100	100	100	100	100	100	100	100	100	100	100	100

It will probably be impossible to prove this explanation experimentally until we can get an explosive whose temperature of detonation is under 650° Cent., the ignition-temperature of marsh-gas, so that the temperature would only suffice to ignite the higher hydrocarbons. The explanation must, however, fail, for all coals the dust of which is known to be explosive, if these contain none of the higher hydrocarbons, as, for instance, No. 13 seam at Hibernia colliery, No. 8 seam at Pluto colliery, and No. 3 seam at Camphausen colliery.

In this explanation, the fact is also overlooked that when a shot is fired pressure is produced, so that the occluded gases are not allowed to escape as into a vacuum, but, on the contrary, are driven into the pores of the coal. If the explanation is a correct one, the author's results would support it far better, seeing that he has found in the occluded gases of the Hutton seam scarcely anything but combustible gases, while Dr. Bedson has found only 20 per cent. of such gases, so that in the former case an explosive mixture would far more readily be formed than in the latter. Further, no attention is paid to the fact that when coal is heated in the presence of air, which corresponds to the actual conditions, quite different products are obtained from those when the coal is heated in a vacuum. The question to be solved is: What gas is produced when coal is heated in the presence of air at low temperatures, up to 650° Cent.? Messrs. Varrentrapp and Richters have already given an answer to the above question, which may be read between the lines of their classical works. Nitrogen must be produced, because the oxygen is absorbed.* In order to get a more accurate idea of the nature of the gases left when coal was heated in air, the author had heated about ½ gramme of coal, in sealed glass-tubes, of a capacity of about 60 to 70 cubic centimetres, in an air-bath to temperatures of 160° to 200° Cent., and had then investigated the residual air. He always heated the coal to above 160° Cent., because he was certain that oxygen would be absorbed at that temperature. At 160° Cent., many coals (he cannot say with certainty all coals) absorbed oxygen with extreme energy. The results are shown in Table II., in which the numbers refer to the same coals as in Table I.

* *Chem. Centr.*, 1865, page 953; and *Dinglers Polytechnisches Journal*, vol. 178, page 379; vol. 190, page 398; vol. 193, page 51; and vol. 195, page 315.

TABLE II.

	IV.	XI.	VII.	VII.	VII.	I.
Nitrogen, N_2	98	96	95	94	94	93
Carbonic acid, CO_2 ...	2	2	2	3	4	6
Olefines, C_xH_y	trace	2	3	3	2	1
Oxygen, O_2	—	—	—	—	—	—
Totals	100	100	100	100	100	100

C_xH_y represents a higher hydrocarbon, which may be determined by calculation from the phenomenon of combustion to be either C_2H_6 or C_3H_8. The author draws, however, definite attention to the circumstance that other products of heating are obtained (for example an acid [?acetic acid]), the gases from which are mixed with the air, are not absorbed by caustic potash, and are combustible. Dr. Bedson has obtained similar products by heating his coals to 184° Cent. in vacuum (as he imagines), and has obtained a residue of air which he has recorded as occluded gas. The composition of this residual gas is as follows:

	Per cent.
Nitrogen	62·6
Carbonic acid	5·8
Paraffins	4·6
Oxygen !	27·0

This result absolutely upsets everything known with regard to coal. Dr. Bedson does not, however, even once point out that he has discovered a new method of producing oxygen! The writer has already pointed out sufficiently how air found its way into his apparatus. How oxygen may have been obtained by heating to 184° Cent. may be explained through the air having been drawn off too quickly, so that it had not time to come into contact with the heated coal. How, however, he obtained 27 per cent. of oxygen is inexplicable.

With regard to Table II., it may be noted that the results refer only to the conditions there given. If a larger quantity of coal is heated in a tube of the above size (70 cubic centimetres), the oxygen contained therein does not suffice for complete oxidation, and some marsh-gas remains. In order to prove this experimentally, the author has heated in a tube of 70 cubic centimetres capacity 6, 4, 2, 1 and ½ gramme respectively of coal No. XI., and

has examined the residual air, with the results recorded in Table III.

TABLE III.

	6 grammes.	4 grammes.	2 grammes.	1 gramme.	½ gramme.
Nitrogen, N_2 ...	85	90	91	95	96
Carbonic acid, CO_2 ...	·1	1	2	2	2
Marsh-gas, CH_4 ...	14	9	7	3	—
Olefines, C_xH_y ...	—	—	—	—	2
Oxygen, O_2	—	—	—	—	—
Totals ...	100	100	100	100	100

With reference to Table III., it may be noted that the content of carbonic acid is remarkably small, less than might have been expected from the quantity of marsh-gas present, the reason being the above-mentioned, that when coal is heated in the presence of oxygen other products than carbonic acid are formed. In the first four analyses, the writer was unable to find these products in the gaseous form (the residual gas was pure marsh-gas), but he was able to prove the invariable formation of some strong acid soluble in water (acetic acid?).

In Tables II. and III., the absence of oxygen is especially indicated, in order to accentuate the fact that it is impossible to find free oxygen in a closed vessel in which coal has been heated. Volumetrically this absorption of oxygen is very important. One part of coal by volume in the form of powder suffices to absorb 50 times its volume of oxygen between 160° and 200° Cent., and to render 250 times its volume of air incapable of explosion. In these results, however, time also plays a part, so that further insistence upon them would be unfruitful.

How then may a coal-dust explosion be explained? As long as we blast with explosives, whose temperature of detonation is above 650° Cent., and which show flame, we have in a blown-out shot a source of heat (not only a source of warmth) which can generate abundant quantities of gas from coal, and at the same time produce a flash, which is capable of firing the explosive gaseous mixture thus formed. One part of gas-coal gives about 300 times its volume of gas when all the latter is evolved. The crusts of coke, which cover everything in the pit after a coal-dust explosion, may be looked upon as coal from which about

half of the gas has been set free. There is, therefore, in a coal-dust explosion evidently no want of combustible gas, though there may be of air. For this reason, the wave of explosion is propagated in the opposite direction to the intake air-current. On its way, it liberates further gas from coal-dust that is thrown up; it, therefore, constantly requires fresh air, and thus continues its course to the downcast-shaft, which it also frequently destroys. In coal-dust explosions, the large volume of air which the miner employs for the ventilation of the mine is a source not of safety but of destruction. The flash of a blown-out shot can cause the ignition of an explosive mixture of gas, but even its presence may be dispensed with, for the powerful pressure which a blown-out shot produces may cause the ignition-temperature of marsh-gas to be attained. Here, however, the conversion of mechanical work into heat does not play the principal part, but the properties of oxygen, which are affected by compression, inasmuch as compressed oxygen has a far more violent oxidizing action than it has under normal pressure. It is, therefore, not a matter of indifference how a shot-hole is placed: whether the shot blows out straight along the centre of the road, whether it lies at an acute angle to the roof or the floor, or perpendicular to the solid mass of coal.

The main factor in a coal-dust explosion is, and remains, the fine state of division of the dust; the second condition is the heating of the dust; while the chemical properties of the coal only occupy the third place. All coals can produce dust-explosions, even coke, which is perfectly free from gas. Supposing that finely-divided coke were flung up by means of a blown-out shot, at a sufficiently high temperature, this would burn to carbon monoxide in the presence of sufficient coke, and produce an explosive mixture with air.

Some coals give off gas at lower, others at higher temperatures; some are dry, others moist; some produce a very finely divided, others a coarse-grained dust, etc. For the production of coal-dust explosions the former conditions require a lighter, the latter a heavier charge of explosive.

Prof. P. P. Bedson read the following paper on "The Gases enclosed in Coal and Coal-dust":—

THE GASES ENCLOSED IN COAL AND COAL-DUST.

By P. PHILLIPS BEDSON.

In the early part of the year 1899, a paper on the subject of the gases enclosed in coal appeared in *Glückauf*,* in which Dr. Broockmann gave an account of the results of his examination for "enclosed gases" of coals of the Westphalian coal-field; and, at the same time, detailed the results of his examination of the Hutton-seam coal, which he had obtained from Ryhope colliery. This coal was submitted to investigation, because Dr. Broockmann had reason to doubt the results obtained by the late Mr. McConnell and the author, which were described in a paper read before this Institute in February, 1894.†

After the perusal of this paper in *Glückauf*, it appeared desirable to re-investigate the question rather than simply replying to the strictures of Dr. Broockmann, with the information then to hand. For this purpose, in November, 1899, the late Mr. McConnell collected samples of coal from the Hutton seam at Ryhope colliery, and the investigation, then commenced, has been continued until the present time. In the summer of 1900, Mr. McConnell was accidentally drowned, while boating off the Northumberland coast, consequently the author has not had the benefit of his assistance; and for information on the work which formed the basis of the conjoint paper already referred to, he has had to content himself with the laboratory-notes and journals left by his friend. This sad event, therefore, made the repetition of a portion of the previous enquiry all the more necessary.

Before describing the results of these recent experiments, it will be best to deal with some of the points raised by Dr. Broockmann in his criticism.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 18.

† *Ibid.*, 1894, vol. vii., page 27.

In the first place, Dr. Broockmann draws attention to the unsuitability of indiarubber, either in the form of tubing or stoppers, for work of this kind, pointing out that it is "as permeable to gases as a sieve is to water." Although the writer readily acknowledges the justice of these strictures on the use of indiarubber, he is unable to agree in the application made by Dr. Broockmann in the description given of the method employed by the late Mr. McConnell and himself: for, in the paper published in the *Transactions* of The Institution of Mining Engineers in 1894, to which Dr. Broockmann gives a reference, it is stated that the coal used in the experiments was contained in flasks sealed on to an air-pump of the Geissler type. Further, it is stated in this paper that "the apparatus used in these and all subsequent experiments was made entirely of glass, the several parts being fused together to prevent leakage."* The properties of indiarubber cannot, therefore, be made responsible, as Dr. Broockmann suggests, for the fact that in one instance as much as 818 cubic centimetres of gas was obtained from 100 grammes of freshly-hewn Ryhope coal; nor are the proportion of the gases of the atmosphere found in this gas and the relatively small amount of combustible gas to be explained in the same manner.

Surely, in a case of this kind, it is not unreasonable to expect that a critic should show an acquaintance with the details of the work under criticism; but, in the paper printed in *Glückauf*, no mention is made of another experiment with the same coal, in which a much smaller volume of gas was obtained, and a gas which contained a relatively large proportion of combustible constituents, nor is any note made of the fact that this difference is specially emphasised. The writer is of the opinion that the large volume of gas obtained in the first instance is explained by the difficulties surrounding the removal of the air adhering to the glass and to the coal itself, difficulties increased by the close packing of the coal in the flask, whereas in the second experiment the coal was loosely filled into a tube, 1⅛ inches in diameter. The amount of coal used in the first experiment, namely, 220 grammes, as against 90 grammes in the second, must also have contributed to the difficulty of removing completely the adherent air.

Dr. Broockmann, in his experiments, took 100 grammes of coal, contained in a vessel sealed direct on to a Sprengel pump.

* *Trans. Inst. M.E.*, 1894, vol. vii., page 32.

The coal was in a finely divided state, being in grains from 2 to 4 millimetres in diameter; and, after repeated exhaustions, the apparatus was allowed to stand for 3 or 4 days, before the heating with a water-bath was commenced. In this way, as Dr. Broockmann states, he obtained a minimum quantity of gas, and he claims that the gas so obtained is truly representative of the "enclosed gases," and is not contaminated by air adhering to the coal, or by those gases produced by the action of the air on the coal itself.

Experimenting with the Ryhope coal, Dr. Broockmann obtained 70 cubic centimetres of gas, which consisted of 97 per cent. of combustible gas, and 3 per cent. of carbon dioxide; that is, from 100 grammes of coal he obtained 67·9 cubic centimetres of combustible gas, and 2·1 cubic centimetres of carbon dioxide. Whereas, as will be seen by reference to the paper by the late Mr. McConnell and the author, they obtained from the same weight of coal 61·07 cubic centimetres of combustible gas, 4·2 cubic centimetres of carbon dioxide, 1·40 cubic centimetres of oxygen and 55·53 cubic centimetres of nitrogen, making a total of 122·2 cubic centimetres.

As the writer's object in studying the gases enclosed in the Ryhope coal was to obtain information which would throw some light on the nature of the combustible gases that he had previously found in the dust from the screening of this coal, the coal was not taken in small fragments, but in such fragments as would permit to some extent of the partial separation (by reason of the differences in rates of effusion) of the denser from the lighter hydrocarbons. Thus, a rough fractionation would be effected, and in the results of the analysis of the several fractions the presence of different paraffin hydrocarbons would be more clearly indicated.

To return to the use of indiarubber-stoppers in investigations of this kind: it is certainly true that in the experiments on the gases enclosed in coal-dust,* the author employed indiarubber-stoppers, but with the precaution that these stoppers were covered by a layer of Faraday cement. In this connection it may be of interest to record the result of a recent experiment on the manner in which vessels closed in this way will maintain a vacuum over a lengthened period. A flask, of about 300 cubic centimetres capacity, was closed by a tightly fitting indiarubber-stopper

* *Trans. N.E. Inst.*, 1888, vol. xxxvii., pages 245 to 256.

through a hole in which was inserted a glass-tube by which the flask was sealed on to a Geissler pump. The cork was carefully covered with Faraday cement, and then the flask was exhausted and closed off from the pump. After standing some two months, the flask was again exhausted, and the gas obtained collected over mercury. A single bubble of gas was thus obtained, the volume of which proved to be approximately 0·2 cubic centimetre. As this experiment was made under conditions practically similar to those described by the author in his earlier papers,* it may be concluded that, in these experiments, the disadvantages arising from the use of indiarubber-stoppers had been satisfactorily overcome.

A second point in Dr. Broockmann's criticism is the assumption that the author had overlooked the results obtained by the Austrian Fire-damp Commission in the examination of certain varieties of coal-dust. This is all the more surprising, since in the paper in the *Transactions* (to which, as had been already mentioned, Dr. Broockmann referred), and also in the account of the lecture given by the writer to the members of the National Association of Colliery Managers at Nottingham,† the work of the Austrian Fire-damp Commission is specially mentioned. That the writer should have regarded the experiments of the Austrian Fire-damp Commission as confirmatory of his own observations cannot appear strange or remarkable, as the author's first paper on the subject was read before this Institute in August, 1888, while the investigation by the Austrian Fire-damp Commission of the coal-dust question was made during the years 1889 to 1891. Further, the conclusion arrived at by the Commission, and cited by Dr. Broockmann, "that the content of dense, easily inflammable hydrocarbon gases increases both the sensitiveness and the dangerous character of a coal-dust," appeared in the Final Report of this Commission published in 1891. This will suffice to show the independence of the two sets of observations.

Another observation of the late Mr. McConnell and the author, selected for special criticism by Dr. Broockmann, was the composition of the gas obtained by heating the coal at 184° Cent. As Dr. Broockmann pointed out, this gas was remarkable for the large percentage of oxygen given in the analysis; but he, unfortunately,

* *Loc. cit.*

† *Colliery Manager and Journal of Mining Engineering*, 1895, vol. xi., pages 30 to 32.

had not troubled to state exactly the conditions under which the gas was produced, nor the volume of gas obtained under these conditions from 100 grammes of coal. Had this been done, the reader of Dr. Broockmann's paper would, in the first place, have been able to appreciate aright the bearing, on the point under discussion, of the experiments made by Dr. Broockmann to demonstrate the nature of the changes produced in air when it is heated in closed tubes with coal to a temperature of 160° Cent. In the second place, the reader would have been compelled to admire the ingenuity of Dr. Broockmann, who credits the writer with the discovery of a new method of preparing oxygen, and this because from 100 grammes of coal he had obtained 2·1 cubic centimetres of oxygen, or barely 3 parts by weight of oxygen from 100,000 parts by weight of coal.

In the paper read before this Institute in February, 1894, will be found a description of the experiment from which this result had been isolated.* And there it will be noted that a definite weight of coal was introduced into a tube, sealed off at one end and at the other end sealed on to an air-pump. After exhausting the air from the tube, the coal was heated for a certain period by passing steam through a jacket surrounding the tube which held the coal. The gas so produced was drawn off; then, after the coal had ceased to yield gas at this temperature, it was heated by passing the vapour of amyl alcohol through the jacket. When the coal no longer yielded any gas at this higher temperature, it was heated for some hours to a still higher temperature, by passing the vapour from boiling aniline through the jacket; and thus the further fraction of gas was obtained, which in this instance formed from 4 to 5 per cent. of the total volume of gas extracted from the coal.

A repetition of this experiment became necessary, in the light of the importance attached to the composition of the gas obtained by this extraction at 184° Cent., and the difficulty in finding an explanation of the proportion of oxygen which it was found to contain; a difficulty made the greater by Dr. Broockmann's statement that the gas was obtained in experimenting with fine coal, whereas it was produced from coal in pieces, and pieces certainly much larger than those he employed in his investigation. It is not inconceivable that, under the conditions of the experiment, the heating of the coal would cause a mechanical breaking-up of

* *Trans. Inst. M.E.*, 1894, vol. vii., page 35.

the pieces of coal, and thus favour the release of oxygen and other gases not already removed in the previous extractions. As to the proportion of oxygen to the other constituents, while the statement in volume per cent. may appear misleading, it should be stated that a careful scrutiny of the actual analytical data, from which these percentages were computed, had revealed an error in calculation. But, even when this correction is made, the proportion of oxygen to nitrogen is larger than the relative amount of these gases in the air. As to the contention that this observation is contradictory of all our knowledge of the mutual behaviour of air and coal at such temperatures, and its refutation by the experiments recorded by Dr. Broockmann, it will be sufficient to point out that the chemical relations of many bodies are altered by conditions of pressure, and that conclusions drawn from the experiments made under increased pressure are not applicable to explain the results of experiments made under greatly reduced pressures. The impossibility of explaining the presence of the constituent gases of the atmosphere in this gas in the manner suggested by Dr. Broockmann has already been referred to, and that oxygen and nitrogen are found in the gases extracted from coal under these conditions is shown by the results of experiments Nos. IV. and V. described below.

Turning now to the results obtained in the recent investigation of the gases enclosed in the Hutton-seam coal, it will be sufficient to point out that the method of extracting the gases is that employed by Messrs. McConnell and Bedson, described in the paper already referred to.* In experiments Nos. I. to IV. the pump employed, to which the tube containing the coal was sealed on, was one of the Geissler type; whereas in No. V. the pump used was a form devised by Prof. Töpler, without taps. After establishing a vacuum in the pump and tube containing the coal, the apparatus was allowed to stand at the ordinary temperature for some days, and then the gas produced in the interval was drawn off. The volume of the fraction of gas so obtained was measured and afterwards analysed. In order to obtain, if possible, a clearer idea of the nature of the combustible constituents, and to demonstrate as far as practicable the composition of these combustible gases, the coal was submitted to a prolonged

* *Trans. Inst. M.E.*, 1894, vol. vii., page 27.

extraction at the ordinary temperature, before heating with steam was resorted to, and in this way a series of fractions was obtained, each being separately analysed.

The writer's engagements have in many instances determined the lengthy duration of some of these operations: but some compensation for this delay may possibly be found in the information supplied by the results of the analyses of the several fractions of gases obtained from the coal under these circumstances.

In experiment No. IV., instead of removing the air from the tube holding the coal in the ordinary way, the coal was filled into a tube, in which it was held in position by plugs of glass-wool; the tube was next drawn out at both ends, and on to these narrow glass-tubes were sealed. By one of these narrow tubes, the tube was sealed on to the air-pump; while to the other, which was over 30 inches in length, a movable vessel containing mercury was attached by a stout indiarubber-tube. The wider section of the tube was surrounded by a second which formed a jacket for the passage of steam, etc. To expel the air from the tube, the tap of the pump was opened, and by raising the vessel containing mercury, the whole was filled with mercury up to the tap of the pump, which was then closed. The movable vessel was next lowered, the end of the glass-tube to which this vessel was attached stood in a vessel filled with mercury, and on removal of the indiarubber-tube there was thus established a rough barometric column, with the coal standing in a partial vacuum. The height of the mercury was found to be approximately 710 millimetres. After standing overnight, the exhaustion was completed in the ordinary way; and after remaining in this condition for 9 days, the gas given off in the interval was drawn off. Thus it will be seen that the coal was sealed off from the air, not by closing the tube by fusion of the glass, but by a barometric column of mercury. This method of exhaustion was practised in experiment No. V. and afforded a quicker means of removing the air from the tube than by the ordinary method of repeated pumpings, and one which consequently yielded a larger amount of combustible gas per given weight of coal.

Below are given in tabulated form the results of the measurements and analyses of the several fractions of the gases extracted from the coal in the manner indicated. The results of experiments Nos. I. and II. are not stated in detail, as the analyses of

the several fractions were not completed. In stating the results, it has been deemed desirable to give not only the percentage composition of the several fractions, but also the absolute volumes of each gas yielded, calculated upon 100 grammes of coal. As previous experience has shown the combustible constituents to be almost entirely members of the paraffin series of hydrocarbons: and as carbon monoxide and olefines have been proved to be absent, or present only in minimum quantities, these gases have been omitted in the statement given below.

TABLE. I.—WEIGHTS OF COAL TAKEN, AND TOTAL VOLUMES OF GAS EVOLVED *IN VACUO* AT ORDINARY TEMPERATURE AND AT 100° CENT.

No. of Experiment.	Duration of Extraction.		Weight of Coal.	Volume of Gas per 100 grammes of Coal.	
	Ordinary Temperature.	Steam-heating.		Drawn off at Ordinary Temperature and at 100° Cent.	Drawn off at 100° Cent.
			Grammes.	Cubic centimetres.*	Cubic centimetres.*
I.	5 days ...	$10\frac{1}{2}$ hours	117·0	148	130·00
II.	27 days ...	31 hours	110·4	108	88·80
III.	10 months and 12 days ...	30 hours	129·6	141	44·25
IV.	9 days ...	$15\frac{1}{2}$ hours	67·0	198	170·30
V.	2 days ...	$49\frac{1}{2}$ hours	70·0	142	119·30

* Volumes of gas given are in all cases expressed in cubic centimetres at 0° Cent., and a pressure of 760 millimetres of mercury.

Since the results of the estimation of the paraffin hydrocarbons do not suffice to allow of a definite statement of the nature of the constituents of the mixture, instead of returning these in terms of a value for n in the general formula C_nH_{2n+2} it has been thought better to interpret the results in terms of a possible mixture of marsh-gas (CH_4) and ethane (C_2H_6) or ethane and propane (C_3H_8) according as the analytical data appeared to warrant. All that is attempted to indicate by this form of statement is simply that the combustible gases are not pure marsh-gas, but that other gaseous members of this series of hydrocarbons are present in the gases. In the majority of cases these numbers are based upon the mean of two or more concordant sets of determinations.

The proportion of such hydrocarbon constituents is determined by taking a measured volume of gas from which oxygen, etc., have been absorbed, mixing it with a measured volume of oxygen and exploding, then by a series of operations determining the amount of the contraction and of carbon dioxide resulting, also the amount

TABLE II. - DETAILED RESULTS OF ANALYSES OF THE SEVERAL FRACTIONS OF GASES EVOLVED *IN VACUO* UNDER STATED CONDITIONS.

Experiments.	No. III.								No. IV.				
	a	*b*	*c*	*d*	*e*	*f*	*a,b,c,d*	*e,f*	*a*	*b*	*c*	*d*	*e*
	Expelled at Ordinary Temperature.				Expelled at 100° Cent.		Expelled at Ordinary Temperature.	Expelled at 100° Cent.	Expelled at Ordinary Temperature.	Expelled at 100° Cent			Expelled at Ordinary Temperature.
Duration of extraction	12 days.	7 m'nths.	1 month.	2 m'nths.	15 hours.	15 hours.	Average	Average	9 days.	2 hours.	8½ hours.	5 hours.	6 months.
Total volume: cubic centimetres	43·57	37·75	35·11	9·23	40·52	16·92	—	—	12·57	41·93	47·31	24·95	6·15
Carbon dioxide (CO_2)	5·48	0·50	1·81	4·08	3·90	7·78	2·84	4·90	7·47	4·86	1·89	—	—
Oxygen (O_2)	2·60	15·23	1·17	0·30	—	—	5·81	—	10·34	—	—	—	—
Marsh-gas (CH_4) ...	59·70	23·76	89·30	87·70	79·70	58·50	59·28	72·50	35·59	86·10	89·67	90·00	98·00
Ethane (C_2H_6) ...	—	—	1·80	6·70	18·20	33·80	0·98	22·50	—	4·28	6·18	10·00	—
Nitrogen (N_2)... ...	32·22	60·51	5·92	1·22	—	—	31·08	—	46·60	4·76	2·26	—	—
	100·00	100·00	100·00	100·00	101·80	100·08	99·99	99·90	100·00	100·00	100·00	100·00	—
	VOLUME OF GAS IN CUBIC CENTIMETRES PER 100 GRAMMES OF COAL.												
	a	*b*	*c*	*d*	*e*	*f*	*a,b,c,d*	*e,f*	*a*	*b*	*c*	*d*	*e*
Carbon dioxide (CO_2)	1·84	0·14	0·49	0·29	1·21	1·00	2·76	2·21	1·40	3·04	1·33	—	—
Oxygen (O_2)	0·87	4·43	0·31	0·02	—	—	5·63	—	1·90	—	—	—	—
Marsh-gas (CH_4) ...	20·07	6·92	24·19	6·24	24·91	7·63	57·42	32·54	6·60	54·00	63·40	33·48	9·00
Ethane (C_2H_6)	—	—	0·48	0·47	5·69	4·41	0·95	10·10	—	2·67	4·36	3·72	—
Nitrogen (N_2)	10·83	17·60	1·60	0·08	—	—	30·11	—	8·70	2·98	1·59	—	—
	33·61	29·09	27·07	7·10	31·81	13·04	96·87	44·85	18·60	62·69	70·68	37·20	9·00

TABLE II.—*Continued.*

Experiments.	No. IV.—*Continued.*			No. V.						
	f	*g*	*h*	*a*	*b**	*c*	*d*	*e*	*f*	*b & c*
	Expelled at 130° Cent.		Expelled at 180° Cent.	Expelled at Ordinary Temperature.	Expelled at 100° Cent.		Expelled at Ordinary Temperature.	Expelled at 130° Cent.	Expelled at 180° Cent.	Expelled at 100° Cent.
Duration of extraction ...	1½ hours.	9½ hours.	1½ hours.	2 days.	22 hours.	27 hours.	—	12½ hours.	6½ hours.	—
Total volume: cubic centimetres	22·41	18·92	17·00	10·75	65·39	18·35	5·91	11·65	16·46	—
Carbon dioxide (CO_2) ...	0·12	1·72	0·76	9·13	8·19	5·09	0·48	4·67	9·98	7·45
Oxygen (O_2)	6·72	10·82	10·17	20·69	0·68	3·59	17·93	4·43	1·48	1·17
Marsh-gas (CH_4)	8·66	16·50	—	2·46	76·80	54·98	7·36	25·90	—	72·24
Ethane (C_2H_6)	9·78	17·50	3·88	—	6·37	16·25	—	41·09	62·15	8·54
Propane (C_3H_8)	—	—	4·66	—	-	—	—	—	20·72	—
Nitrogen (N_2)	74·72	53·46	80·53	67·72	7·96	20·09	74·23	23·91	5·67	10·60
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

VOLUME OF GAS IN CUBIC CENTIMETRES PER 100 GRAMMES OF COAL.

	f & g	Per cent.	*h*	*a*	*b*	*c*	*d*	*e*	*f*	*b & c*
Carbon dioxide (CO_2) ...	0·52	0·84	0·15	1·39	7·56	1·33	0·04	0·74	2·24	8·89
Oxygen (O_2)	5·29	8·58	2·11	3·16	0·46	0·94	1·50	0·73	0·34	1·40
Marsh-gas (CH_4)	7·55	12·24	—	0·37	71·70	14·40	0·61	4·30		86·10
Ethane (C_2H_6)	8·21	13·32	0·70		5·94	4·25	—	6·82	14·61	10·19
Propane (C_3H_8)	—	—	0·96		-	- -	—	--	4·86	—
Nitrogen (N_2)	40·08	65·02	16·75	10·36	7·43	5·22	6·24	3·97	1·33	12·65
	61·65	100·00	20·67	15·28	93·09	26·14	8·39	16·56	23·37	119·23

* After withdrawal of sample *b*, an accident to the pump resulted in an admission of air. The pump was repaired, and after re-exhausting, the experiment continued.

of oxygen which has been used in the combustion. From these data, the information desired can be obtained, but owing to the difficulties surrounding the exact determination of the oxygen, the writer has, in computing the results, neglected the values found for the oxygen used. This mode of interpreting the results appears to be better than that used in the previous paper, since the amount of contraction and the proportion of carbon dioxide are data capable of more exact estimation, than is the determination of the amount of oxygen used; so the influence of experimental errors in making this last estimate is avoided. If this mode of calculation be applied to the analytical data obtained in the previous investigation, the proportion of combustible gas would then appear somewhat higher.

Table II. contains a statement of the results of the examination of the gases obtained in the several experiments, and from these a series of averages have been calculated, based upon the results of experiments Nos. III., IV. and V., and are contained in Table III. In the first column of figures are given the volumes in cubic centimetres of the several gases obtained from 100 grammes of coal; in the second column the composition of the gas is expressed in volumes per cent.; while in the third column of figures the analyses have been calculated on the assumption that the oxygen existed as air.

These numbers call for one or two remarks. In the first place, the total volume of gas per 100 grammes of coal obtained at 100° Cent. is not very different from that given in the paper of the late Mr. McConnell and the writer. In experiments Nos. III. and IV. (Table II.), it will be noted that the gas expelled by steam-heating was free from oxygen, and in one instance consisted entirely of combustible gas. In experiment No. IV., whereas the last extract at 100° Cent. was free from oxygen, the next extract at a higher temperature contained oxygen. The improbability of this being derived from the outside air (which would necessitate the assumption of a leakage from the tap) is rendered all the greater in the light of the results in experiment No. V., in which similar results were observed; and, as has been already pointed out, in this experiment a pump was employed without taps.

The composition of the gas obtained in the first extraction of experiment No. V. is worthy of special attention, as, in addition

TABLE III.—AVERAGE RESULTS OF EXPERIMENTS NOS. III., IV. AND V.

A.—GASES EXTRACTED AT ORDINARY TEMPERATURES AND AT 100° CENT.

	Cubic Centimetres.	Volume. Per Cent.	Volume. Per Cent.
Total volume ...	160·90	—	—
Carbon dioxide (CO_2)	7·02	4·36	4·36
Oxygen (O_2)	4·53	2·81	—
Marsh-gas (CH_4) ...	114·50	71·17	71·17
Ethane (C_2H_6) ...	10·65	6·62	6·62
Nitrogen (N_2) ...	24·21	15·05	4·42
Air	—	—	13·44

B.—GASES EXTRACTED AT 100° CENT., AND INCLUDED IN A.

	Cubic Centimetres.	Volume. Per Cent.	Volume. Per Cent.
Total volume ...	111·53	—	—
Carbon dioxide (CO_2)	5·15	4·62	4·62
Oxygen (O_2)	0·46	0·41	—
Marsh-gas (CH_4) ...	89·84	80·60	80·60
Ethane (C_2H_6) ...	10·34	9·27	9·27
Nitrogen (N_2) ...	5·74	5·10	3·55
Air	—	—	1·96

C.—GASES EXTRACTED AT 130° CENT.

	Cubic Centimetres.	Volume. Per Cent.	Volume. Per Cent.
Total volume ...	39·09	—	—
Carbon dioxide (CO_2)	0·63	1·61	1·61
Oxygen (O_2)	3·01	7·70	—
Marsh-gas (CH_4) ...	5·92	15·14	15·14
Ethane (C_2H_6) ...	7·51	19·21	19·21
Nitrogen (N_2) ...	22·02	56·34	27·19
Air	—	—	36·85

D.—GASES EXTRACTED AT 180° CENT.

	Cubic Centimetres.	Volume. Per Cent.	Volume. Per Cent.
Total volume ...	22·01	—	—
Carbon dioxide (CO_2)	1·19	5·40	5·40
Oxygen (O_2) ...	1·22	5·54	—
Marsh-gas (CH_4) ...	—	—	—
Ethane (C_2H_6) ...	7·65	34·76	34·76
Propane (C_3H_8) ...	2·91	13·22	13·22
Nitrogen (N_2) ...	9·04	41·08	20·12
Air	—	—	26·41

to carbon dioxide, it contains a considerable proportion of oxygen, and an amount in relation to the nitrogen in excess of that in which these gases occur in air. The coal used in this case was

taken from a sample which had been kept in an open tube in the laboratory for several months, and this exposure to the air suggested itself as the explanation of the proportion of oxygen: for the coal-substance would not only lose gas, but would absorb gases from the air—and preferentially oxygen rather than nitrogen. The explanation was submitted to a direct test, and for this purpose a tube about 1 inch in diameter was sealed on to the Töpler pump, the open end dipping under mercury. By exhausting the air from this, a barometric column was established, and into the space above pieces of coal were introduced by immersing them under the mercury in the cistern and allowing them to rise through the column of mercury. After the coal had remained some days in the exhausted space, the gas was drawn off and analysed.

From freshly-hewn coal, the gas obtained in five days (18 cubic centimetres) was found to have the following percentage composition:—

	Volumes.	Volumes.
Carbon dioxide (CO_2) ...	1·65 ...	1·65
Oxygen (O_2)	8·99 ...	—
Marsh-gas (CH_4) ...	44·60 ...	44·60
Nitrogen (N_2)	44·76 ...	10·73
Air	— ..	43·02

From coal of the same origin, which had been exposed to the air of the laboratory for several months, a volume equivalent to 14·5 cubic centimetres was obtained in 17 days, which was found to have the following composition:—

	Volumes.
Carbon dioxide (CO_2)	1·18
Oxygen (O_2)	23·80
Marsh-gas (CH_4)	3·58
Nitrogen (N_2)	71·44

On standing over mercury for a month a further quantity of gas was given off, measuring 16·2 cubic centimetres, and composed as follows:—

	Volumes.
Carbon dioxide (CO_2)	0·64
Oxygen (O_2)	20·91
Marsh-gas (CH_4)	4·52
Nitrogen (N_2)	73·93

These results support the explanation given of the proportion of oxygen found in the first fraction of gas obtained in experiment No. V., and show, in addition to the readiness with which the coal loses marsh-gas, that it absorbs oxygen from the air more

readily than the nitrogen. This suggests that the interpretation of the oxygen found in the enclosed gases as representing a corresponding proportion of air must be accepted with a certain amount of reserve. Nevertheless, this assumption has been made in stating the results in the foregoing tables, and may be permitted, as in almost every case there is sufficient nitrogen to mix with the oxygen.

The proportions of the combustible gases found and their nature sufficiently well support the writer's views expressed on a former occasion as to the manner in which the denser hydrocarbons are retained by the coal, and support the explanation given of their existence in the gases enclosed in the dust formed in screening this coal. It should be noted that in experiment No. III., the combustible gas extracted at the ordinary temperature is not entirely marsh-gas.

As to the application of the existence of these hydrocarbon gases enclosed in the coal-dust to explain the part played by coal-dust in an explosion, it has never been maintained that they are the only factors determining the sensibility to ignition of the dust, nor as pre-eminently more important in this regard than the fineness of sub-division or the dryness of the dust. Still, the practical experience with this dust at the colliery, which first suggested the investigation, sufficiently demonstrates the ready inflammability of this coal-dust; and these facts, taken together with the results of the examination of the enclosed gases of other coal-dusts, justify the conclusion advanced in previous publications.

The Chairman (Mr. J. G. Weeks), in moving a vote of thanks to Prof. Bedson, who had dealt with the question most exhaustively, thought that there would be no doubt that he had refuted the arguments of Dr. Broockmann.

Mr. C. C. Leach, in seconding the vote of thanks, said he had noticed that his firemen preferred to use coal taken from the small-coal heap; and Prof. Bedson's explanation of the facility with which coal exposed for some time to air would absorb oxygen probably accounted for their preference.

The vote of thanks was cordially adopted.

Mr. Edward Halse's paper on "Some Silver-bearing Veins of Mexico" was read as follows:—

SOME SILVER-BEARING VEINS OF MEXICO.
(*Continued.*)*

By EDWARD HALSE.

ZACATECAS.

The classic region of Zacatecas, in the state of the same name, was discovered by Juan de Tolosa, in 1546, since which date it has produced immense quantities of the white metal. It has an extension from north to south of about 9¼ miles, and 7½ miles from east to west. The city itself is situated in the southern portion of the district on the slopes of the Grillo, Bufa and Bolsa hills, at an elevation of 8,178 feet above the sea.

Zacatecas may be described as a group of mountains separated by plains of varying elevations, the whole really forming a portion of the central plateau of the republic. The mountains seldom rise far above the plains, and their flanks have, as a rule, a comparatively gentle slope.

The principal country-rock of the district was formerly regarded by Mr. Laur† as a grauwacke (*vacia gris*), although Dr. Burkart‡ and most Mexican geologists considered it to be a diorite. Later researches have shown that the formation is a green rhyolitic tuff, associated with a rock—probably an altered andesite—similar to that of the famous La Luz district of Guanajuato.§ Besides the above there is a sedimentary rock—a black slate, frequently siliceous—which passes by insensible degrees into the volcanic tuff and andesite (?), and diorite proper, which in places is metamorphosed into chloritic schist. At a depth, varying from 800 to 1,000 feet, the favourable country (rhyolitic tuff and

* *Trans. Inst. M.E.*, 1900, vol. xviii., page 370; 1901, vol. xxi., page 198; and 1902, vol. xxiii., page 243.

† "De la Métallurgie de l'Argent au Mexique," *Annales des Mines*, 1871, series 6, vol. xx., page 33.

‡ *Aufenthalt und Reise in Mexico in den Jahren 1825 bis 1834*, Stuttgart, 1836.

§ *Trans. Inst. M.E.*, 1902, vol. xxiv., page 54.

andesite ([?] or diorite) passes insensibly into black argillaceous schist* with kidneys of milky quartz, in which the veins rapidly become impoverished.

Dykes of diorite (*feldstein* of Dr. Burkart) traverse the region, and, among other rocks, mention may be made of trachyte, rhyolite and quartz-porphyrite (bird's-eye porphyry), limestone of Cretaceous age, and conglomerates of two ages, the more recent of a red colour containing fragments of the above-mentioned rocks in a paste of clay, the older one being purple in colour,† and composed, in addition to fragments of the same rocks in a felspathic cement, of large masses or boulders of decomposed granite, abounding in mica and pegmatite, formed of crystals of quartz, felspar and very little mica.

The slates of Catorce are, for the most part, of Jurassic age, but the age of the clay-slate or ampelite (*hoja de libro*) met with in depth in Zacatecas and Guanajuato has not yet been determined. The red conglomerates of both districts belong to the Upper Tertiary (Pliocene), and there is reason to believe that the majority of the veins were formed after the consolidation of that rock.

The veins of Zacatecas have a general north-west to south-east strike, the prevailing dip being southerly. There are, however, many exceptions to this rule. The principal ones, like the Veta Madre (mother-lode) of Guanajuato, are apt to be split up into branches separated by more or less altered country-rock. As in the Veta Madre, three branches are frequently distinguishable, known as the hanging- (*cuerpo de alto*), centre- (*cuerpo del enmedio*) and foot-branch (*cuerpo de bajo*). However, Dr. E. Tilmann pointed out that,‡ in the case of the Veta Madre, a distinct tripartite arrangement of the lode is very improbable, and, as a matter of fact, the latter is frequently split up into more than three branches, especially on the lying side, and the same is probably the case in Zacatecas.

It has already been shown§ that the large veins of the Taviches

* This must not be confounded with the black slate found near the surface, in which the veins are frequently profitable (*e.g.*, at the Bote mine).

† At the San Rafael mine, there is purple conglomerate at the surface and diorite below. The richer, which go down only about 400 feet, are continuous in length while in the conglomerate.

‡ *Der Bergbau von Guanajuato*, 1866, page 19.

§ *Trans. Inst. M.E.*, 1900, vol. xviii., page 381.

district of Oaxaca are in places split up into several branches, and, by referring to Fig. 3 (Plate XVIII.),* it will be seen that these are mainly on the lying (or eastern) side of the lode, as in Guanajuato.

Francisco de P. Zárate says† that the ores of these so-called branches vary considerably in structure. Thus, in the veins of Malanoche, Veta Grande and La Plata, the ore on the hanging-branch is of a banded structure, being formed of layers or ribs of silver ores separated by country. This ore is usually the best. The middle-branch also has a ribboned structure—the silver-ores are, however, symmetrically arranged in quartz or calcite. The footwall-branch is composed of iron-pyrites, galena and blende scattered with native silver,‡ black sulphide of silver, and complex sulphides (ruby silver, etc.), so intermingled as to constitute a *pinta revuelta*. These ores are sometimes arranged concentrically, forming nodules (*en boleo*), and, no doubt, coating fragments of country-rock, forming what Prof. F. Pošepný terms "crusted kernels."§

The writer had no opportunity of studying the larger veins of this district, but he made a careful examination of a group of veins to the south of the city, which bear gold as well as silver.¶

Fig. 1 (Plate I.) is a sketch-plan of some of these veins. The strike varies from north 14 degrees west to north 28 degrees west,|| and the dip is easterly from 55 to 80 degrees.

* *Trans. Inst. M.E.*, 1900, vol. xviii., page 384.

† *Apuntes sobre la Mineria del Estado de Zacatecas*, Zacatecas, 1884, 98 pages.

‡ The writer has suggested in another paper ("On Deep Mining in Mexico," *Transactions of the Institution of Mining and Metallurgy*, 1895, vol. iii., page 425) that where native silver is associated with iron-pyrites "its reduction is probably in some way connected with the presence of that mineral." It is well known that a silver salt is readily precipitated by ferrous sulphate, and Mr. S. F. Emmons says, "with an excess of ferrous sulphate present, as near the outcrop of ore-deposits, this might account for the separation of native silver from silver salts, while on the other hand with an excess of ferric oxide the silver might be carried further down in solution." ("The Secondary Enrichment of Ore-deposits," *Transactions of the American Institute of Mining Engineers*, 1900, vol. xxx., page 213). As a matter of fact, native silver in Mexico is found (1) in gossan, with or without unaltered pyrites, (2) with iron-pyrites to some distance below the outcrop, and (3) in rare instances, as at Batopilas, Chihuahua, immediately below iron-pyrites (see Prof. C. B. Dahlgren's *Historic Mines of Mexico*).

§ "The Genesis of Ore-deposits," *Transactions of the American Institute of Mining Engineers*. 1893, vol. xxiii., page 197.

¶ Several years ago, the writer endeavoured to show that a gold-bearing belt of considerable economic importance occurs south of Zacatecas city, *Engineering and Mining Journal*, 1894, vol. lviii., pages 78, 105-107 and 605-606.

|| Magnetic declination about east 8¼ degrees.

The No. 1 vein courses north 14 degrees west and dips eastward 80 degrees. It is small and compact, varying from 7 to 20 inches in thickness, in a dark-coloured slate-rock which appears to be chloritic schist (probably altered diorite) impregnated with iron-pyrites. The structure of the vein is shown in Figs. 2 and 3 (Plate I.). In Fig. 2 (Plate I.), the vein consists of quartz with ribbony streaks of sulphides, principally argentite (Ag_2S),* and fine native gold on either wall, separated by calcite, exhibiting rhombohedral structure here and there, which forms the centre of the vein. In Fig. 3, the quartz and calcite are in alternate layers, but in this instance calcite is on the hanging-wall and quartz on the foot-wall, while a layer of quartz occupies the centre of the vein. The rib of quartz on the foot-wall carries some streaks of sulphides and native gold on the side farthest from the wall. The colour of the quartz is white, pinkish or bluish (when impregnated with silver-sulphide), the calcite being white or pale green. In an *arroyo*, a little north of the *hacienda*, similar country is seen to course north-east to south-west and to dip southeastward, 35 degrees.

The No. 3 vein runs about north 30 degrees west and dips eastward 60 to 70 degrees. The workings in this vein were, in 1894, only about 90 feet in vertical depth, and had not reached water-level. The vein consists of solid bands of quartz, stained and ribboned by black sulphide of silver, etc., separated by bands and masses of calcite, the whole coloured a deep red by oxide of iron, in a schistose country-rock. The thickness of the vein varies from 3 to 5½ feet, the average being about 4 feet. Where the vein is wide, it is generally split up by horses of country-rock, although the average value of the vein-contents remains about the same. Figs. 4 and 5 (Plate I.) will give some idea of this structure. On the foot-wall side (Fig. 4), there is a selvage of white clay, 1 foot thick. The foot-wall joint is well defined and dips 60 degrees eastward.

The No. 4 vein strikes nearly north-and-south and dips eastward 75 degrees, meeting the No. 3 vein on the line of strike. The workings here were 150 feet deep, but water-level had not

* Also called (black) sulphide of silver and silver-glance, in this paper.

been reached, although oxidation was only traceable to a vertical depth of 100 feet. The thickness varies from 3½ to 6 feet, the average being about 4½ feet. It would appear to be a contact-vein, for the hanging-wall consists of greenish diorite impregnated with iron-pyrites, while the foot-wall is a greyish schist. Figs. 6, 7 and 8 (Plate I.) exhibit the structure. The centre of the vein is sometimes occupied by country, 4 feet thick (Fig. 6); elsewhere (Fig. 7) the filling is solid quartz with sulphides of silver, etc., in streaks and spots. In the bottom workings, ribbony streaks of sulphides carrying finely-scattered native gold are distinguishable in the six bands of quartz, which are separated from each other by calcite (Fig. 8).

The No. 7 vein strikes north 20 degrees west, uniting with a north-and-south vein or branch about 80 feet from the shaft. The dip is 70 degrees eastward. The vein consists of bluish quartz ribboned with sulphides and some calcite, separated by bands and masses of the latter mineral. The walls are schist, trending east-north-east to west-south-west and dipping southward 50 to 70 degrees. The bedding-planes appear to roll a good deal. The width varies from 2 to 3 feet. Fig. 9 (Plate I.) shows the structure. Here a thick clay-selvage lines the hanging-wall.

The San Cristobal, a little north of the last, is a parallel vein running about north-north-west, and dipping 60 degrees eastward. The width varies from 4 to 12 feet. In a shallow working in the same vein, the structure illustrated in Fig. 10 (Plate I.) was seen. The vein in one place had been worked to a depth of upwards of 300 feet, and it would seem that the ore-body pitched at an angle of 66 degrees in the northerly direction of the strike. The hanging-wall, near the surface, has a clay-selvage with slickensides. When the calcite has an opaque white-and-pink mottled (or altered) appearance, and the quartz is flinty and streaked with sulphide of silver, the ore is generally of good grade.

The banded structure of these veins is seldom, strictly speaking, symmetrical, and the writer believes that it has been produced partly by the substitution and partly by the re-opening of the original country.

The calcite appears, generally, to be of more recent date than

the quartz, nevertheless some quartz has been deposited since the former, for in the No. 7 vein several cavities in the calcite were seen to be lined with crystals of quartz, and here and there the quartz and calcite are so intermixed that they would appear to have been deposited contemporaneously.

The sulphide of silver has been deposited by preference on the quartz, although here and there it is said to occur in calcite, or to have crystallized out between the two minerals.

Another noteworthy fact is that the calcite shows a tendency to disappear in depth. This would almost seem to indicate that this mineral is the result of surface-decomposition produced by water carrying carbonic acid in solution,* but it must be remembered that limestone occurs in the district in patches. Altered limestone is found in some portions of the Bote mine (some of the veins of which are distinctly gold-bearing) and although the veins there contain on an average about 80 per cent. of silica, a good deal of calcite occurs in some of the lower levels (depth of mine about 800 feet in 1894). Hence it would appear more probable that the carbonate of lime has been brought into the veins, both laterally and from the surface, by direct solution of limestone-rock.

A little to the south of the above-described group of veins is a large outcrop of trachytic rock known as La Mesa del Cerillo. This rock cuts off all the veins in that direction,† so it is most probably of later origin.

The schistose country has been considerably altered close to the contact—the rock has a mottled red-and-purple colour, and the schistose structure is more or less obliterated. One of the veins, which is traceable almost up to the line of contact, consists mainly of quartz showing some ribbons of argentite, but the vein is considerably bent and ramified, and contains many lenticular inclusions of country-rock.

The veins carry from 6 to 38 ounces of silver, and from 10 to 60 dwts. of gold to the ton. The ratio of gold to silver varies considerably in the different veins, and in different parts of the same vein, but the average may be taken as 1 to 10 in weight, and

* *Trans. Inst. M.E.*, 1901, vol. xxiii., page 253, footnote.

† In the mining districts of Tatatila and Zomelchuaca (State of Jalisco?) silver-veins occur in limestone, and never penetrate trachyte, against which they terminate abruptly (Prof. Von Groddeck).

as 4 to 1 in value (taking silver at 2s. 1d. or 50 cents per ounce troy).

The *caracol* structure, already described* is sometimes met with in these veins. The gold is associated here and there with chlorobromide of silver or embolite (*plata verde*†) and brown ochreous iron.

The following additional notes on this district have been gathered from various sources:—

The Veta de la Cantera, one of the largest veins of Zacatecas, can be traced some miles east-south-east of the city. It has a general north-west to south-east strike, but, where it sweeps round the northern edge of the hill of grey trachyte, known as La Bufa,‡ it has been bent considerably out of its normal course.

About 1¼ miles west of the city, or in the region of the Bote mine, the lode is divided up into several more or less parallel branches or veins, similarly to the Veta Grande between Panuco and Zacatecas, and here it once more assumes a general north-west to south-east course. The dip of the main vein is southerly.

La Cantera vein, where formerly worked in its eastern portion, trends north 70 to 75 degrees west and south 70 to 75 degrees east, dips southward 48 degrees and is from 16½ to 98½ feet thick. According to Mr. F. Sescosse, the vein itself is almost sterile, but here and there it is enriched by transverse veins which are themselves poor. They may be called branches, as they go from the body of the vein in a north-easterly direction, but do not pass to the south. Nevertheless the foot-wall portion of the vein bears traces only of complex ores containing lead and zinc, the rich and docile ores being confined to the hanging-wall for a width of 6½ to 19½ feet.

At the Bote mine, the ores of this and parallel veins consist of argentite, with some ruby silver and other high-grade ores, and free gold associated with iron-pyrites (not abundant). In the upper levels, silver occurs both native and as chloride and bromide. At this mine, a distinction is drawn between silver-

* *Trans. Inst. M.E.*, 1901, vol. xxiii., pages 250, 251 and 254.

† At Catorce, *plata verde* is bromyrite, a mixture of bromide and iodide of silver.

‡ *Bufa* in Mexico is the name given to a narrow ridge of rock standing above the general surface, the sides being very steep. The bufas a little south of Guanajuato city are formed of a greenish porphyritic rock (? trachyte).

bearing veins proper and those carrying gold as well. According to Mr. Enrique Wiüst, the former run north 49 degrees west and dip southward 75 degrees, and the latter north 58 degrees west, the dip being 64 degrees in the same direction—hence they meet both horizontally and vertically.

A few veins in this district course about east and west, and dip northward in black slate. The ores are galena, pyrites, blende (abundant), and pyrargyrite (*rosicler oscuro*). To the south of Malanoche, the San Clemente vein has a similar trend and dip; the ores, native silver, chloride of silver (*plata azul**) and argentiferous pyrites, occur in rich bunches or shoots (*ojos* or *tramos*). To the east of Malanoche is the *mineral* of San Bernabé, in which, according to tradition, the first mines worked by the *conquistadores* are situated.

The San Miguel and San Luis veins have no well-defined walls or selvages, and in places the silver-ore is disseminated in the rock, but following a certain direction (Dr. F. de P. Zárate). At the Mina de los Clérigos—ore, sulphide of silver, native silver and ruby silver—the walls of the vein (strike north 47 degrees west, dip northward 49 degrees) are said to be a kind of conglomerate, and the riches occur between 328 and 559 feet (Mr. E. Wiüst).

If the country-rock be identical with the red conglomerates, it proves that the vein which courses through it was formed, like the Veta Madre, after the consolidation of that rock, and fixes the age of the vein as later Pliocene or Post-Pliocene.

Guanajuato.

The city of Guanajuato, in the state of the same name, is situated about midway between the Pacific Ocean and the Gulf of Mexico, in 24 degrees north latitude and 108 degrees west longitude. It lies at an elevation of 6,724 feet above sea-level on the south-western slope of a range of mountains, known as the Sierra de Guanajuato, which trends north-west and south-east, dividing the central plateau of Mexico into two unequal por-

* At Zacatecas, *plata azul plomillosa* is argentite (the *plata azul* of Tlalpujahua). *Plata azul acerada* is polybasite; *plata azul de Catorce* is selbite or carbonate of silver. Dr. Del Rio, the geologist, gives the name *plata azul* to a silver-bearing copper-ore.

tions, the eastern plains, or those nearest the gulf, having less lateral extent, and being of somewhat higher altitude than the western plains.

The Sierra itself rises to a maximum height of about 9,500 feet above sea-level. The hills in the neighbourhood of Guanajuato city range from about 6,888 to 7,954 feet (the height of the Sirena mountain), while the lowest working on the Veta Madre or mother-lode in the deep Valenciana mine is still 4,484 feet above sea-level.

The surface-geology of the Guanajuato district, which extends about 12 miles from north-west to south-east, and 9 miles from north-east to south-west bears some resemblance to that of Zacatecas, although it is, if possible, still more complex. An older sedimentary formation, consisting of clay-slate, calc-schist, running here and there into pure calcareous layers, and grauwacke, with some beds of rather fine conglomerate, of unknown thickness and of undetermined age,* extends for some distance to the east of the city and for a considerable distance to the north of it, striking in a general north-westerly to south-easterly direction and dipping south-westward from 40 to 50 degrees, while the predominating rock around the city itself, and right away to the alluvial (Quaternary) plains to the west, is a red conglomerate, or rather breccia, of Pliocene age,† with a similar strike, but dipping eastward. The breccia is at least 2,000 feet thick.

Some distance north-west of the city, the Luz group of veins occurs in a greatly altered eruptive, which has been termed "diorite," as well as other classes of greenstone (*roca verde*)—probably altered andesites and rhyolites.

Just south of the city is a large outcrop of recent argillaceous

* Formerly regarded as Silurian or Devonian, but no rocks of these ages have as yet been identified in Mexico. Thin black layers of anthracite occur in the clay-slate. The older sedimentary rocks of this area are certainly pre-Cretaceous, and may be Triassic, or possibly Carboniferous (corresponding perhaps to the Culm-measures of Great Britain).

† Of the same age as that occurring at Zacatecas (*Trans. Inst. M.E.*, 1902, vol. xxiv., page 42), and in the neighbourhood of Tasco (*Trans. Inst. M.E.*, 1901, vol. xxi., page 208). The red conglomerate of Guanajuato was formerly regarded as Triassic (New Red Sandstone). According to Prof. E. Tilmann, it is made up of more or less angular fragments of schist, grauwacke, and various greenstones (diorite and porphyry predominating) in an argillaceous cement stained by red oxide of iron. The fragments are often upwards of 2½ feet (70 centimetres) thick.

sandstone called *losero*,* and, beyond the clay-slate to the east, the Villapando and Santa Rosa group of veins is found in so-called "porphyry," an eruptive or prior date to the diorite of La Luz.

According to Prof. Tilmann, the clay-slate and grauwacke owe their present inclined position to the breaking-through of the porphyry, while the diorite supplied the material of the red conglomerate.

Besides the above rocks, there are numerous dykes and masses of hornblende, granites (syenites) of pre-Cretaceous age, more especially near the contact between the clay-slate and diorite, as well as recent emanations of trachyte, basalt, etc.

Among the metamorphic rocks of the area may be mentioned chloritic schist, hornblende-schist and serpentine. Here and there, the two latter, together with syenite, are found in sheets overlying the clay-slate.

A long series of eruptions must have taken place here during the Tertiary period. The order of eruption in this particular district appears to have been (1) andesite, (2) rhyolite, (3) trachyte and (4) basalt. The vein-fractures, especially those of the Veta Madre, were probably formed during the ejection of the trachyte. After the filling of this lode, there was considerable erosion of the eruptive, forming the sedimentary deposit known as *losero*, which covers a large portion of the outcrop south of the city. Finally, the hot springs now issuing in the neighbourhood of the basalt prove that deep subterranean disturbances are still in progress.

Fig. 13 (Plate II., after Prof. Tilmann) shows the surface-geology and the principal veins of the district. The general parallelism of these is much more marked than is the case at Zacatecas. They course, with few exceptions, from north-west to south-east, and dip south-westward.

The Veta Madre has an average strike of north 38 degrees west. At the Cardenas mine (depth 600 feet, and now abandoned)

* This rock also occurs at Tasco (*Trans. Inst. M.E.*, 1901, vol. xxi., page 208). Baron A. von Humboldt (*Essai Politique sur le Royaume de la Nouvelle-Espagne*, 1811) describes the Guanajuato rock as a felspathic conglomerate composed of grains of quartz and small fragments of felspar in a ferruginous cement. Prof. St. Clair Duport (*De la Production des Métaux Précieux au Mexique*, 1843) calls it a grit containing fragments of felspar. Prof. E. Tilmann describes it as a very fine conglomerate lying almost horizontally on the red conglomerate in grey, blue, violet, red and yellow stripes. The new dam at Guanajuato (capacity 1,600,000 cubic metres) is made of this rock, known as *cantera* by the quarrymen.

to the south, the strike is north 25½ degrees west; from the Cedro mine (depth 500 feet and now abandoned) to Sirena, it is north 34½ degrees west. Between Sirena and a little north of Valenciana, where the greatest wealth occurs, the lode takes a wide sweep, first westward (north 50 degrees west) and then eastward (north 33 degrees west), the average trend of this portion of the vein being north 47½ degrees west. From Valenciana to a little north of Santa Gertrudis, the vein courses north 31½ west. North of this point, the average strike is north 37 degrees west and the dip 45 degrees south-westward.

The Veta Madre was somewhat incorrectly termed a bedded vein by Prof. Von Groddeck.* It is true that both strike and dip correspond more or less with the schistose rocks, but it is undoubtedly a fissure-vein; and it is worthy of note that the richest portion of it corresponds with the line of contact between the red conglomerate (hanging-wall) and the clay-slate (foot-wall), and that in the latter rock the vein is split up into several branches, most of which contain ore in payable quantities.

Prof. Von Groddeck pointed out that the Veta Madre must have shifted the beds of conglomerate about 13,120 feet (4,000 metres) laterally. Prof. Tilmann makes no mention of any such displacement as this. If such a shifting took place, it probably happened long before the Veta Madre was formed. This lode, for a portion of its course, may occupy an old line of fault, formed, perhaps, during the emission of the granitic rocks, for the line of least resistance from pre-Cretaceous times has been in a general north-westerly to south-easterly direction. When the fracture, or series of fractures, occurred in Tertiary times, this fault may, therefore, have been re-opened for a considerable portion of its length. The new fracture would appear to have been propagated from a north-westerly direction (the centre of the disturbance may have been in the neighbourhood of the Gigante mountain), for, on meeting the dense beds of conglomerate, it was deflected eastwards, following the line of contact between that rock and the clay-slate, and the forces of rupture, rebounding from the denser beds of conglomerate, tore open, as suggested by Prof. Tilmann, the fissile beds of clay-slate—hence the numerous branches on the lying side of the vein, where the conglomerate forms the hanging-wall, and which decrease in number, until they finally disappear

* *Lehre von den Lagerstätten der Erze*, 1879.

farther south. On meeting the solid mass of conglomerate at Sirena, the fracture was deflected or refracted in an opposite direction, cutting through these beds perpendicularly, or, in other words, following the line of least resistance of that rock.

The principal veins of Villapando, San Nicolas and Santa Rosa run strictly parallel to the Veta Madre, as will be seen by referring to Fig. 13 (Plate II.). The parallelism of the Luz system of veins is not so noticeable. The main vein (Plateros) has an average strike of north 56 degrees west. It was probably formed contemporaneously with the Veta Madre, but failed to penetrate the hard red conglomerate to the south. The direction of La Luz (north 15 degrees west) is exceptional—it appears to be a caunter* vein to the Plateros.

The Villapando and Santa Rosa veins are interesting, from the fact that they bear gold as well as silver. It is said that the old mines here produced ore yielding between 26½ and 68 dwts. of gold to the ton.

One vein, near Villapando, examined by the writer, strikes from north-north-west to north-west and dips southward from 55 to 65 degrees. It is about 3 feet in width, the structure of the vein being sometimes brecciated and sometimes banded. The ore contains from 10 to 12 ounces of silver, and from ½ to 1½ ounces of gold per ton—the average gold-contents being about 12½ dwts. The beds of country-rock trend north-north-eastward and are nearly perpendicular.

A vein near San Nicolas courses east and west, and dips 52 degrees southward, the thickness being upwards of 13 feet, with good streaks of ore on both walls. The structure is generally brecciated; the country-rock is slate and "porphyry." The shoots of ore in this mine have a tendency to pitch westward.

Near Santa Rosa, one vein, now being worked, runs north-and-south and dips westward, while another courses north-west

* In Cornwall, "a metalliferous vein 30 degrees to 60 degrees from east and west" (Mr. J. Carne); "a lode 40 degrees to 50 degrees from the general strike" (Mr. R. W. Fox); and "a lode making a considerable angle, not exceeding 45 degrees, with the normal lode of the district. If it exceeds 45 degrees it becomes a cross-lode" (Mr. Salmon). *Caunter* is generally derived from Latin *contra* (English *counter*), against, but Mr. Salmon thinks that it is allied to *caunt* or *cant* (to tilt over or incline).

to south-east with a similar dip. About 124 feet of soft greenish country (" porphyry ") separates the two at the point examined. The former vein is from 1½ to 3 feet and the latter from 3½ to 6½ feet thick. The north-and-south vein has a good leader (*cinta*), 6 inches thick, on the hanging-wall. The best ore from these veins contains about 55 ounces of silver, while the gold-content only amounts to 12 grains to the ton.

According to Prof. Tilmann, the Luz vein was denounced a short time after the conquest, but was not worked in a formal way until 1845 by Mr. Perez Galvez.

The Luz group of veins* is famous for having yielded several very rich *bonanzas*. Two very rich shoots of ore, about 200 feet in length, were followed to a depth of 1,312 feet in the northern portion of La Luz, and another, almost equally rich, was proved for a length of 164 feet and followed to a like depth, in the southern portion of the Plateros vein.

The two veins cross each other obliquely; at the junction they run together for a length of 656 feet. It is a remarkable fact that the north-western portion of the Plateros vein (strike north 60 degrees west and dip southward 60 degrees), and the southern portion of La Luz (strike north 15 degrees west, and dip westward 60 degrees) had not been wrought when Prof. Tilmann wrote his memoir, the riches having been discovered only on the eastern limbs of the cross, or those nearest to the Veta Madre.

All the veins shown in Fig. 13 (Plate II.), with the exception of Melladito, dip southward—the latter vein, which is from a mere parting up to 49¼ feet thick, dips north-eastward 45 degrees (termed *contra natural* by the miners), and therefore meets the Plateros vein on the dip. At the junction, there is a complete splitting up of both veins, as many as seven branches having been opened out, which separate farther south and become insignificant.

The filling of the La Luz vein (thickness 13·12 to 16·40 feet) is quartz and calcite with many beautiful druses. When the vein is productive, the chief filling consists of a dark green friable

* In the description of these veins, and of the Veta Madre, which follows in the text, the writer is largely indebted to Prof. E. Tilmann's memoir, "*Der Bergbau und das Amalgamations-verfahren in den Bergwerks-distrikte von Guanajuato in Mexico*," 73 pages, 5 folding plates, Münster, 1866. He is less chary of quoting from this work as it has been out of print for some years, and is now scarce.

talcose mass, finely sprinkled with silver-ores, termed *jabones*.* The silver-ores consist of stephanite (brittle silver-ore), the whole range of silver-bearing blendes, and light and dark ruby-silver.†

In the Plateros vein, the ruby-silver is very finely sprinkled in hard quartz, stephanite occurring as well where the gangue contains some calcite. The thickness of this vein varies considerably, from a mere salband to about 19½ feet—the average being about 9·80 feet.

The small veins (thickness 2½ to 6½ feet) of this group contain black threads of silver-ore (ruby and brittle silver) in compact quartz.

The ores known as *jabones* are found also in the Veta Madre, but of a white colour, being more calcareous. They are probably the result of the decomposition of the original matrix by solutions containing silver-ores, forming here and there distinct shoots or columns. The silver-ores may have been brought into the veins long after they had been filled with veinstone (quartz and calcite); but, more probably, they were leached out of the veins themselves, and redeposited as sulphides in certain portions of them, forming what has been termed secondary enrichments.‡

The two ore-shoots of the La Luz vein produced silver to the value of £6,000,000 in 15 years, the average yield of the ores being 137 ounces to the ton—masses of *jabon*, besprinkled with ruby silver and stephanite, being in some places upwards of 39¼ feet thick. The ore-shoot of the Plateros vein produced silver worth about £1,000,000.

Between the ore-shoots of the La Luz vein, the filling is quartz and calcite in beautiful crystals, said to be quite sterile. The average thickness of the vein is about 9·84 feet (3 metres), the country being a highly-altered green eruptive. For this reason the rock is extremely difficult to determine. According to Mr.

* At Villa Nueva, Honduras, *jabon* (soap) is an extremely friable, whitish-grey, talcose, clayey rock, containing small fragments of broken highly siliceous rock, and charged with a quantity of gold- and silver-sulphides. Mr. A. J. Bourdariat, *Trans. Inst. M.E.*, 1895, vol. viii., page 623.

† According to Prof. Tilmann, a solid piece of light ruby-silver (proustite), 25 pounds in weight, was taken out of La Luz mine, and presented to the Emperor Maximilian.

‡ "The Secondary Enrichment of Ore-deposits," by Mr. S. F. Emmons, *Transactions of the American Institute of Mining Engineers*, 1900, vol. xxx., page 177. Mr. Emmons believes that secondary enrichment is generally produced by descending surface-waters, although he has a strong impression "that not i frequently the ascending currents have also produced migrations of already f rmed deposits and local enrichments under favouring conditions."

Ezequiel Ordoñez,* certain specimens from this district, examined microscopically, were found to approximate to andesitic porphyrites and hornblende-andesites.

The ore-bearing in these veins, as in all those of Guanajuato, begins at a depth of 262 feet (80 metres).

The Veta Madre, where it has conglomerate on the hanging-wall and clay-slate on the foot-wall, has an enormous thickness, for example:—in Valenciana, 492 feet; farther south in La Cata, 426½ feet; and in Mellado, 328 feet. The conglomerate is impregnated with iron-pyrites and silver-ores, forming pockets here and there. The clay-slate is also sprinkled with iron-pyrites, and for the width already stated, contains numerous branches, leaders, bunches and spots of ore separated by more or less dead country-rock. The branches, in number up to 8 or 10, in thickness from 5 to 26¼ feet, run sometimes parallel, sometimes unite in strike as well as dip and again separate. Here and there solid masses of ore occur from 98½ to 131¼ feet thick. In the Mellado mine, one ore-body was as much as 197 feet in thickness.

Fig. 11 (Plate I., after Prof. Tilmann) will give some idea of the ore-occurrence. The section was taken in the Cata mine, at a depth of 385 feet. It will be seen that the branches of ore are separated from each other by country-rock—as much as 90 feet in thickness of clay-slate divides the lying-branches from those on the hanging-wall. The total thickness here is 165 feet.

The structure of the separate branches is sometimes banded (Fig. 12, Plate I., after Messrs. Aguilera and Ordoñez), and sometimes brecciated, fragments of country-rock of all sizes occurring in the vein-filling. The amethyst, quartz and other minerals are sometimes aggregated in small particles and fragments; they sometimes occur in leaders or ribs, which are rarely continuous, sometimes parallel to the walls, and sometimes in curved or circular forms. The ores are seldom in solid masses, but more often occur as thin coatings on the veinstone or inclusions of country-rock, or are very finely scattered throughout.

So far as the writer is aware, very little information, other than statistical, has ever been published about this master-lode. It is to be hoped that the Geological Institute of Mexico will soon supply the deficiency, and indeed publish a monograph on

* "Bosquejo Geológico de México," *Boletín del Instituto Geológico de México*, 1896, núms. 4, 5 y 6, page 260.

this district that will compare favourably with the admirable one on Pachuca.*

The number of druses in the vein proves that there were many open spaces when the first filling took place—no doubt re-opening, substitution and local concentrations or enrichments have occurred from time to time since, gradually building up the complex lode as we see it to-day.

Amethyst and calcite, with larger and smaller irregular pieces of country-rock, form the chief filling. The mass of the vein is composed, in addition, of ordinary quartz, brownspar, talc, dolomite and rhodonite, while gypsum, spathic iron-ore, fluorspar, apophyllite (in beautiful crystals), asbestos, mountain-leather and hyaline quartz are more or less rare.

The ores include native gold (generally very finely scattered, sometimes as a thin coating, and rarely in small solid particles), native silver (solid, scattered, as a thin coating, hair-shaped, arboriform, etc.), silver-glance (solid, crystalline, hair-shaped and filiform), among the rarer ores, and nearly always dispersed, are stephanite, light and dark ruby-silver, fahlerz, galena and blende. Copper-pyrites (*bronze malo*) and iron-pyrites (*bronze bueno*) are largely disseminated throughout the lode—the latter generally silver-bearing. There is a notable absence of hornsilver and heavy-spar in this lode.

At the Providencia mine (depth 71 feet), where the most northerly workings are situated, clay-slate forms both walls; the vein is from 6½ to 26¼ feet thick and compact—in other words, it is not split up into several branches, as is the case in the Valenciana, Cata, Mellado and Rayas mines farther south. The prevailing matrix is amethyst, finely scattered with silver-ores. Between Rayas and Sirena, only one branch is known, from 6½ to 16½ feet thick. At Sirena, where the lode is once more powerful, it is being actively exploited by the Guanajuato Consolidated Mining and Milling Company. This mine has a depth of about 984 feet. South of the *losero* formation, where both walls are composed of conglomerate, the maximum thickness of the vein is only about one-half of what it is at Providencia.

Mr. Obregon, a Spaniard, began to work the Valenciana mine, in 1760, on borrowed capital. By 1766, he had reached the critical

* "El Mineral de Pachuca," *Boletín del Instituto Geológico de México*, 1897, núms. 7, 8 y 9, 184 pages and 14 plates.

depth of 262½ feet (80 metres). The following year he was joined by Mr. Otero, and, during the next forty years, this mine was worked 4,264 feet along the strike and 3,116 feet on the dip. From 1788 to 1824, Valenciana produced silver worth £6,872,663, the net profit during this period being £2,571,242. It is a remarkable fact that, during those 37 years, the mine only showed a loss in 1810, when the surface-plant was burnt down during the war of liberation.

The total depth of the mine is 1,968 feet. The main shaft is 36 feet in diameter and 1,771 feet deep. It is octagonal in shape, and lined with masonry to a depth of 328 feet. The above depth was attained by means of horse-whims only*—and the shaft had to be of colossal dimensions in order to employ as many of these as possible. The Valenciana mine has upwards of 10 miles of underground workings, and is still the deepest and the most extensive mine in the republic.

It is a mistake to suppose that the enormous lode wrought was full of rich ores: although rich patches undoubtedly occurred here and there, the average grade was not very high, and Baron A. von Humboldt is probably correct in stating that it was below 80 ounces of silver to the short ton. In 1865, the average of all ores won from the Veta Madre, according to Prof. Tilmann, amounted to 43·7 ounces of silver per short ton, and 30 grains of gold per mark (8 ounces) of silver. The ore in the bottom workings of Valenciana is said to be rebellious, containing much antimony and lead.

The town of Valenciana rapidly came into existence during the most flourishing period of this great mine. At times, the inhabitants numbered as much as 30,000. A handsome church was built, and luxuriously furnished by the owners, at a cost of £144,000.

It is melancholy to record that, after the expulsion of the Spaniards, the mine, the greater portion of which had been under water for a whole decade, was mismanaged by a British company for about 12 years. After 5 years' incessant pumping, the water was forked, by means of a badly-constructed steam-engine and numerous horse-whims, at the enormous cost of £184,000.

* The ore was raised from the various plats in sacks made of the fibres of the agave or of ox-hide, called *mantas*; while the water was hoisted in large bags made of ox-hide, termed *botas*, each holding from 75 to 200 gallons of water.

Various lower levels were opened up, but the undertaking was finally abandoned in 1836 with a sum of £160,000 to their debit. Since that date, the lower levels have remained under water, although, from time to time, the mine has yielded a profit from ores obtained from the upper workings.

The Cata mine was first worked in 1700. In consequence of the great profits raised therefrom, the King of Spain made the principal owner Marquis of San Clemente. The depth is about 984 feet.

The Mellado mine (depth 1,312 feet) was worked as far back as the sixteenth century. This and the Rayas mine caused the building of the present city. For three centuries, the production of this mine was unbroken, but unfortunately the data of the former workings were lost in 1810. A British company worked the mine on contract from 1825 to 1837, losing about £20,000. Afterwards, the owners worked it again at a considerable profit. Lead- and antimony-ores predominate in the bottom-workings, as at Valenciana.

The Rayas mine has a main shaft 1,312 feet deep, measured vertically, and 39·36 feet (12 metres) in diameter. The gold- and silver-contents are unusually high, quartz, very finely scattered with gold, termed *guijo de oro* by the miners, being not uncommon. A British company also worked this mine on contract, and, notwithstanding the glaring incapacity of the officials, made a clear profit of £400,000, which was speedily squandered away in other undertakings.

Judging by the longitudinal section of the mines on the Veta Madre,* the ore-shoots have a tendency to pitch south-eastward.

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* Prof. E. Tilmann's memoir, plate II., which is a plan and longitudinal section of the mine from Providencia to Mellado inclusive. *The Engineering and Mining Journal*, 1901, vol. lxxii., page 534, gives a longitudinal section, including a portion of the above, and carrying it farther south, so as to include the Rayas and Sirena mines. Several views of the Sirena surface- and underground-works are also given.

ADDENDUM.

Prof. William P. Blake describes the rocks from La Luz to San Bernabe* as "metamorphic clay-slates, quartzites and conglomerates. In some places the rocks are dioritic, either from metamorphism or by reason of the intrusion of dykes. All the formations are uplifted, and are flexed and contorted, so that the dip is variable. There is abundant evidence of pyritic mineralization, the rocks being everywhere rusty and red at the surface."†

The east-and-west vein near San Nicholas‡ is evidently a cross-vein. There are actually many of these veins in the district, and, according to Prof. P. Aguilar, they probably follow the cleavage-planes of the clay-slate country-rock.

The country-rock referred to as "porphyry" in the text, is principally rhyolitic-porphyry, and all veins occurring in it carry high-grade gold-ore, containing, generally, free gold, but in exceptional cases selenides and tellurides, or gold contained in the iron-pyrites.

According to Prof. Blake "the chief veinstone or gangue of the veins of La Luz§ is a compact white quartz, with some calcite carrying argentite, pyrargyrite, stephanite, polybasite, miargyrite, and sometimes a little cinnabar. There is a considerable amount of disseminated iron-pyrites, and there are small quantities of galenite. At Bolenitos, the chief silver-mineral is the simple sulphide of silver (argentite)."‖ In addition to the above, apophyllite may be added, which occurs in beautiful pink and white crystals in the Refugio mine.

Prof. Blake, referring to the Veta Madre,¶ says, "the vein is described as in three distinct parts, separated by country-rock or *tepetate*, and named *blanco* (24 metres); *verde* (15 metres), and *negros* (10 metres). Including the barren intervals, the aggregate width of the vein is 125 metres. The white (*blanco*) ores shown me consisted chiefly of quartz with disseminated silver sulphides; the black ores (*negros*) contained much iron-pyrites, sometimes

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 49.

† "Notes on the Mines and Minerals of Guanajuato," *Transactions of the American Institute of Mining Engineers*, 1901, vol. , page

‡ *Trans. Inst. M.E.*, 1902, vol. xxiv., page 52. § *Ibid.*, page 53.

‖ *Transactions of the American Institute of Mining Engineers*, 1901, vol. page .

¶ *Trans. Inst. M.E.*, 1902, vol. xxiv., page 55.

carrying argentite in small particles, and distinct crystals of argentite from the bottom of the shaft."*

The CHAIRMAN (Mr. J. G. Weeks), in moving a vote of thanks, said that the members were once more beholden to Mr. Halse for a valuable contribution to the *Transactions*.

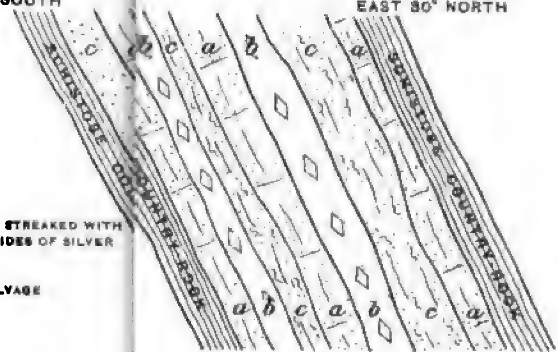
Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. W. C. BLACKETT described an "Improved Offtake-socket for Coupling and Uncoupling Hauling-ropes;" as follows:—

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. , page .

WEST 30° SOUTH

EAST 30° NORTH



a, QUARTZ, STREAKED WITH SULPHIDES OF SILVER

b, CALCITE

c, CLAY SELVAGE

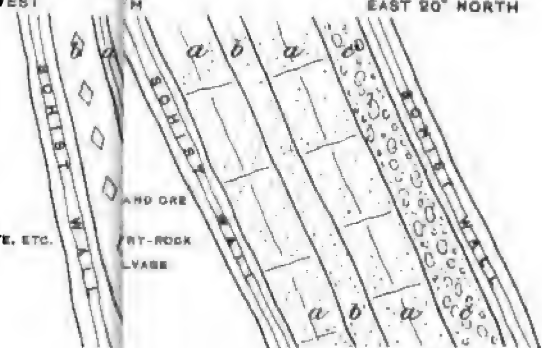
FIG. 5.

Scale, 4 Feet to 1 Inch.

Inch.

WEST

EAST 20° NORTH



a, QUARTZ WITH STREAKS OF ARGENTITE, ETC.

b, CALCITE

AND ORE

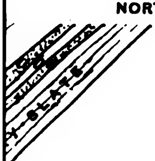
RY-ROCK

LVAGE

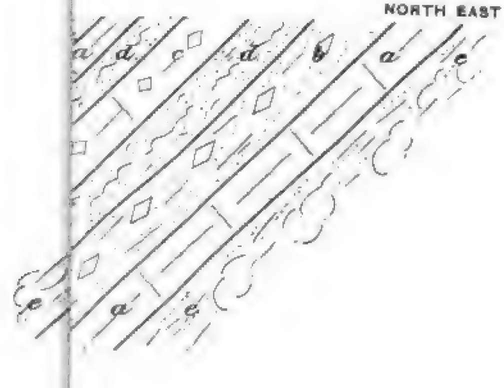
FIG. 9.

Scale, 4 Feet to 1 Inch.

NORTH EAST

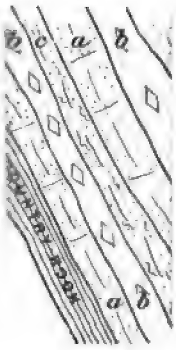


NORTH EAST



EINLETS OF WHITE QUARTZ.

E AND VEINLETS OF QUARTZ.



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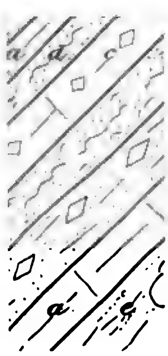
AND ORE

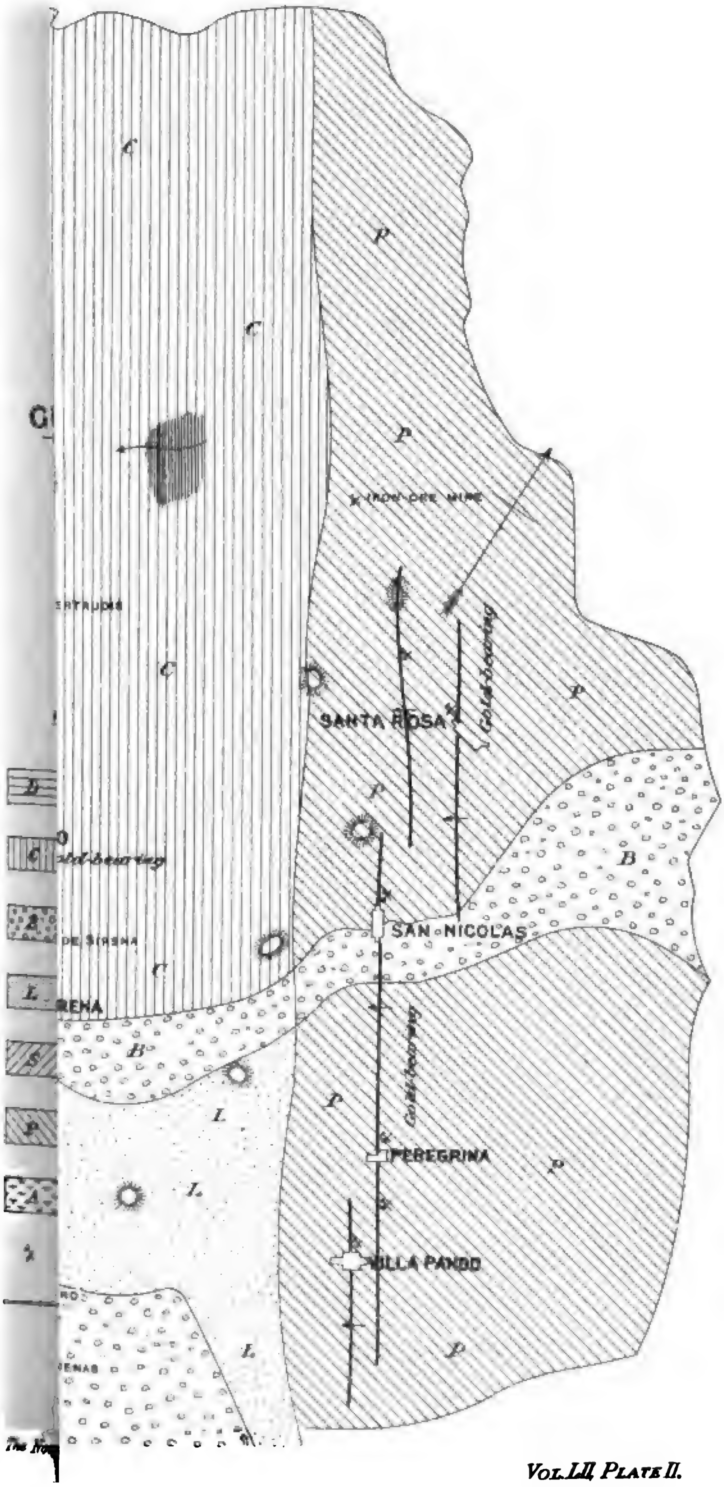
RY-ROCK

LVAGE



EINLETS OF WHITE Q

'S AND VEINLETS OF (


IRON ORE MINE
SANTA ROSA
Gold-bearing
SAN NICOLAS
PEREGRINA
VILLA PANDO

IMPROVED OFFTAKE-SOCKET FOR COUPLING AND UNCOUPLING HAULING-ROPES.

By W. C. BLACKETT.

The improved socketing contrivance for haulage purposes, which the writer had lately devised, was intended mostly for use underground. It was principally intended as an improvement upon the appliances now in use for the quick coupling and uncoupling of ropes at way-ends, but other uses would doubtless suggest themselves to the members.

Fig. 1.

Fig. 1 illustrates both the old arrangement (AB and CDE) and a variety of the new contrivance (F, G, H, I and J). In the old arrangement, A is the socket, similar in many respects to that

already described by the writer,* in which the rope is held by means of a tapered copper plug; B and C are the offtake-key and slotted lock or box, used for ready detachment; D is a swivel for avoiding any " spin " that there may be in the rope; and E is the socket at the other end.

Instead of this somewhat lengthy arrangement of links, the new device substitutes two sockets, both of which may be like F, with a connecting-piece, G, joined as shewn at J; or the connecting piece, G, instead of being rigid, may be linked. But it is, perhaps, preferable that an ordinary socket, H, should be attached to a socket, I, which again may be either rigidly joined or preferably have an interposed link.

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* *Trans. Inst. M.E.*, 1901, vol. xxiii., page 10.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING OF ASSOCIATES AND STUDENTS,
HELD AT NEWBOTTLE COLLIERIES, SEPTEMBER 3RD, 1902.

NEWBOTTLE COLLIERIES.

MARGARET PIT.

The Margaret pit is one of a group of nine pits comprising the Newbottle collieries, belonging to the Lambton Collieries, Limited. It is situated in the parish of Newbottle, about 1½ miles south-east of Penshaw station.

There are two pits, both of which are downcasts, one being 12 feet and the other 8 feet in diameter. This latter pit was sunk in 1774, and has been drawing coals continuously since that date.

The ventilation is produced by a Waddle fan situated at a ventilating-pit, 1,500 feet from the colliery, and producing 160,000 cubic feet of air, with a water-gauge of 1½ inches at 54 revolutions per minute.

Four seams are being worked at this colliery, namely:—

Coal-seams.	Depth from Surface. Feet.
Main	474
Maudlin	564
Brass Thill	654
Hutton	690

The system of working in the Brass Thill seam is longwall, and in the other seams, bord-and-wall. The output is 800 tons per day.

There are 7 Lancashire boilers at this pit, each 8 feet in diameter, 30 feet long, and working at a pressure of 80 pounds per square inch. The boilers are fitted with Proctor mechanical stokers.

Electrically-driven Coal-cutters.—The generating-plant, which was not specially erected for driving the coal-cutting machines,

has been in existence for several years for hauling, pumping and winding. It was installed in 1891, and except for the renewals of certain parts, it remains exactly to-day as it was at that time. The engines for driving the generating dynamos are of the Willans high-speed type, two in number, each being equal to 140 indicated horsepower, at a speed of 380 revolutions per minute. The steam-pressure is 80 pounds per square inch. Each engine has two cylinders, 17 inches in diameter, with a stroke of 8 inches. There are two generating dynamos, driven by means of link-leather belts, 18 inches wide, and each capable of giving out 80 ampères at a pressure of 780 volts, when running at a speed of 500 revolutions per minute: this is equal to an output of 84 horsepower.

The coal-cutters are of the diamond type of disc coal-cutter. Each cutter is driven by two series-wound motors at a pressure of 500 volts. The revolutions of the cutter-wheel are about 12 per minute. The diameter of the cutter-wheel, with cutters and boxes fixed, is 6 feet 4 inches. The average depth of the cut is usually a little over 5 feet, and the height of the cut is 4½ inches. The power required to work each coal-cutter is on an average about 15 horsepower. Each machine is controlled by a reversing-switch fitted with resistances. The machine is drawn along the face, and kept up to its work by a rope-hauling arrangement, fixed to the end of the machine and worked by ratchet-gear from the driving-shaft.

The Brass Thill seam, in which the coal-cutting machines are working, has not previously been worked at these collieries, owing to the bands of stone which it contains. An average section of the seam is as follows:—

	Ft.	In.	Ft.	In.
Coal	0	10½		
Band	0	8		
Coal	0	11		
Band	0	3		
Coal	1	0		
			3	8½

Its inclination is about 1 in 36, dipping eastward. It is overlain by a roof of mild blue metal, and it has a hard fire-clay floor. The seam is entirely free from water, and fire-damp has not been found.

The coal-cutter kirves in the upper band, that is, above the level of the machine.

There are three coal-cutters at work in the seam, only two of which work at any one time, the third machine being kept as a spare one in case of breakdown.

Houghton Pit.

The chief feature of interest here is a Corliss valve-gear hauling-engine, situated on the surface, supplied with steam at a pressure of 50 pounds per square inch. This type of hauling-engine is somewhat of an innovation, and has given capital results.

The Waddle fan, 21 feet in diameter, produces 280,000 cubic feet of air per minute at a water-gauge of 1·5 inches, and 100 revolutions per minute.

Philadelphia Engine-works.

The whole of the scrap-iron from the various collieries is collected at the forge, where it is used again for new work. The forge is fitted with suitable cranes, and a 15 cwts. hammer (steam being supplied from a boiler placed over the heating-furnace), and is capable of turning out forgings up to 3 tons in weight.

At the brass-foundry, the process of melting and moulding was shown, and also the method of preparing moulds from patterns.

The pattern-store contains thousands of patterns of various kinds, for castings, weighing from a few ounces to several tons.

The boiler-shop is fitted with drilling, shearing and punching machines, and a cold saw. A jigging-screen and coal-belt was seen in course of erection; and also a new boiler for a tank-locomotive.

The smiths' shop contains a tool-fettling and case-hardening furnace; and the work in progress included the manufacture of springs, pit-cages and chains.

The general store is the distributing centre of materials to all the collieries. At the fitting, erecting and machinery shop, locomotives were seen in course of reconstruction, and a locomotive-tender, a steam-hoist, and a mechanical screening-plant were being erected.

Herrington Pit.

Here are two high-speed Waddle fans, each 25 feet in diameter, and capable of producing 250,000 cubic feet of air per

minute, with a water-gauge of $2\frac{1}{2}$ inches, at 100 revolutions per minute. The fans are coupled to a twin-drift, fitted with steel butterfly-doors. The special feature of the arrangement of these fans is that there are two separate fans and two separate engines to drive them, instead of the usual arrangement of a spare engine and only one fan. The work of erecting these fans has just been completed, and they are now running satisfactorily.

Lambton Sanitary Pipe-works.

The process of pipe-making was traced from the dumping-ground for fire-clay, to the crushing-rolls, elevators, and pipe-machine; from the machine to the drying-sheds; thence to the kilns; and, lastly, the finished product was seen stored ready for market.

The show-room contains samples of various specialties, and the more highly-finished products are stored therein.

Chemical Laboratory.

The apparatus for testing gas coal was inspected, including the process of taking the illuminating-power by means of a photometer. The laboratory is used for the testing of gas coal, for the analysis of water, oils, steel, etc., and for the investigation of all chemical and quasi-chemical matters connected with colliery work. Some interesting microscopic specimens were shewn.

To the King's Most Excellent Majesty.

The Humble and Dutiful Address of
The North of England Institute of Mining and Mechanical Engineers

Most Gracious Sovereign,

The North of England Institute of Mining and Mechanical Engineers (Incorporated by Royal Charter in 1876) beg leave humbly to approach Your Majesty's Throne on the Occasion of the August Ceremony of the Coronation of Your Most Gracious Majesty and of our Most Gracious Queen Alexandra, and to tender Sincere and Heartfelt Congratulations on the Auspicious Event.

We desire to present our Ardent and Sincere Wishes for Your Majesties' Health and Welfare. We also Fervently Pray that Your Majesties may wear with Glory and Happiness the Crown of this Kingdom and Empire, and long continue to Reign over a Happy, Prosperous and United People.

Witness our Hands and Seal, the twenty-first day of June, 1902.

JOHN GEORGE WEEKS, President.
SEAL. M. WALTON BROWN, Secretary.

HOME OFFICE, WHITEHALL,
4th September, 1902.

SIR,

I am commanded by the King to convey to you hereby His Majesty's thanks for the Loyal and Dutiful Address of The North of England Institute of Mining and Mechanical Engineers on the occasion of Their Majesties' Coronation.

I am, Sir,
Your obedient Servant,
A. AKERS DOUGLAS.

The Secretary to The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
To Celebrate the Jubilee of the Formation of the Institute,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
September 16th, 1902.

Sir LINDSAY WOOD, Bart., President, in the Chair.

The members and visitors were received by the President, Sir Lindsay Wood, Bart., who afterwards delivered the following address: —

ADDRESS.

By Sir LINDSAY WOOD, Bart.

I beg to thank you for the honour that you have conferred upon me in electing me for the second period your President. It is at all times a great honour to preside over so important and influential a body of gentlemen as compose the members of the North of England Institute of Mining and Mechanical Engineers, but it is a still greater honour to occupy that post on so memorable an occasion as the present one, which is the fiftieth anniversary or Jubilee of the formation of this Institute.

On an occasion such as this, I think it is my duty to review shortly the past history of the Institute, and to endeavour to shew whether or not, and to what extent, the objects of the founders have been carried out and whether the results they anticipated have been realized.

For some time previous to 1851, considerable loss of life had been and was taking place in working the coal-mines of Great Britain; and it was with an universal desire to stop or reduce to a minimum this loss of life, that in 1835, a Committee of the House of Commons was appointed to enquire into the causes of the accidents which were taking place; and they reported that

they regretted that the result of their enquiry had not enabled them to lay before the House any particular plan by which the accidents in question might be avoided with certainty; and consequently they made no decisive recommendation.

In 1839 (resulting from a serious explosion at St. Hilda's colliery, South Shields), a Committee of South Shields gentlemen was appointed and sat for 3 years. They made a report of great value, and came to several conclusions. Among other matters they reported that with regard to safety-lamps: "No mere safety-lamp, however ingenious in its construction, is able to secure fiery mines from explosion."

In 1845, Sir Henry de la Beche and Dr. Lyon Playfair were appointed by the Government to institute enquiry into the causes of accidents in mines and particularly as to inflammable gases. These gentlemen reported recommending the appointment of inspectors of mines, and the compulsory use of safety-lamps in all fiery mines.

In 1849, a Committee of the House of Lords was appointed. They reported the evidence that they had taken, and drew attention to that part of it regarding the appointment of inspectors of mines, and improvements in safety-lamps and of ventilation generally.

In the same year, Mr. Blackwell and Prof. Phillips were appointed to investigate and report on the ventilation of mines. They reported that they considered superior practical and scientific knowledge was required in some districts, and superior skill and unsleeping vigilance in the over-looker; which they thought would be promoted by the establishment of provincial mining schools, and by systematic inspections under the authority of Government.

In 1850, an Act of Parliament was passed appointing inspectors of mines.

In 1851, a Committee of the House of Commons, with Mr. Cayley as chairman, was appointed, and made various suggestions, not generally of a practical character, but they reported recommending the use of the steam-jet as being the most powerful and at the same time, the least expensive method of ventilating mines.

Notwithstanding all these investigations and recommendations, the loss of life from accidents in mines did not decrease,

and it was under these circumstances that a meeting of mining-engineers and gentlemen connected with the working of mines in the North of England, was held at the Coal Trade Office, Newcastle-upon-Tyne, on July 3rd, 1852, "for the purpose of forming a society, to meet at fixed periods and discuss the means for the ventilation of coal-mines, for the prevention of accidents, and for general purposes connected with the winning and working of collieries." Forty-four gentlemen attended that meeting, and it was unanimously resolved that "a society be formed of coal-owners, viewers, and others interested in collieries" for these purposes; and such was the commencement of the Institute which I now have the honour of addressing; and I regret to say that out of the 44 gentlemen attending that meeting only 7 are now living.

Your first President, Mr. Nicholas Wood, in his inaugural address, set out very fully the reasons for the formation of the Institute, and the object for which it was formed, and I trust that it may not be considered inappropriate if I quote his own words on these subjects, for I firmly believe that the desire and hope of the promoters of this Institute, expressed by him in that address, have during the long period of 50 years which has elapsed since it was read, been carried out, and have met with the accomplishment of the belief then expressed. He stated, as the reasons for the formation of the Institute that:—

> We may hope that . . . we are entering upon an undertaking which may be of essential utility to the important interests entrusted to our charge, and which may be the means of averting some at least of those dreadful and deplorable catastrophes which have too often been felt with such disastrous consequences to the district and to the sufferers by their occurrence; and that it may be the means of raising the profession to a higher standard of intelligence in literature and science than it has hitherto attained.
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> * * * * * * * * * * * * * * *
>
> The object of the Institution is two-fold:- Firstly, by a union or concentration of professional experience to endeavour, if possible, to devise measures which may avert or alleviate those dreadful calamities which have so frequently produced such destruction to life and property, and which are always attended with such misery and distress to the mining population of the district. Secondly, to establish a literary institution more particularly applicable to the theory, art and practice of mining than the institutions in the locality at present, or which are within the reach of the profession in this locality.
>
> * * * * * * * * * * * * * * *
>
> We wish the principles of the Institution to be understood. It is an Institution of practical miners associated together to endeavour by a combination of practical knowledge, by an interchange of practical experience and by united and combined effort to improve ourselves in the science of our profession, and by

acting together as a body we may be the instruments of preventing as much as practicable the recurrence of those dreadful catastrophes . . . and at the same time to raise the art and science of mining to its highest practicable scale of perfection in safety, economy and efficiency.*

Having given you the reasons for the formation of the Institute and the objects which the founders had in view, I will now endeavour to shew how far during the last 50 years these have been carried into effect.

During the first year of the existence of the Institute, 143 members joined, and year by year they continued to increase for 25 years, when the total membership reached 971 (in 1877). For a short period after then, the numbers somewhat decreased, but after 1891 it rapidly increased, until this year, 1902, it reached 1,238 members. Therefore, so far as membership is concerned, the Institute has undoubtedly prospered, and clearly shews that there is a widespread desire to obtain the information contained in the papers which have been read and from the discussions which have taken place on them.

The prosperity of an Institute such as this, does not, however, depend upon the number of its members, although financially this is perhaps important: but it is the character of the papers which are contributed by the members, and the discussions which take place on them, that create the value of the Institute, and I think that if we refer to the 51 volumes of our *Proceedings*, 38 of which were published before The Institution of Mining Engineers was formed, and 13 published in their *Proceedings*, we shall find an enormous mass of the most valuable information on almost every subject which is of use or interest to the mining profession. Geology, as might naturally be expected, has been a very fruitful subject on which papers have been contributed, mineralogy, chemical and physical investigations, surveying, mining technology (including as it does so many important subjects connected with mining), metallurgy, machinery, electric investigations, railway and transport, administration, statistics, and many other subjects have been dealt with.

In addition to these 51 volumes of *Proceedings*, the Library of the Institute contains 8,629 volumes and 2,489 pamphlets, all of which are valuable books of reference.

* *Trans. N.E. Inst.*, 1852, vol. i., second edition, pages 13 and 14.

I consider, therefore, that I am justified in claiming for this Institute that, in carrying out the objects set forth by its founders, the members have by an interchange of practical experience and by a united and combined effort to improve ourselves in the science of our profession, raised the art and science of mining engineering to a greatly higher state of efficiency than it was 50 years ago; and this progress of the utility of the Institute and the good work that it was doing was recognized by the Government, for in the year 1876 Her late Majesty Queen Victoria granted to us a Royal Charter.

Between the years 1869 and 1875, five similar institutions to this were formed in the different parts of the mining districts of Great Britain and carried on successfully, each reading their own papers and circulating them among their members, but many valuable papers did not obtain the widespread circulation which their value to the mining industry justified. It was, therefore, about 1887 that a scheme was devised for a federation of these institutes and matured in 1889. There are now six Institutions federated together under the title of The Institution of Mining Engineers. The scheme is undoubtedly a good one, for under it each local association still maintains its own individuality, reading and discussing its own papers, but each member of the local associations receives the papers and discussions of the other local associations, which form the membership of The Institution of Mining Engineers, as well as the papers and discussions thereon which are read at the meetings of The Institution of Mining Engineers, held twice in each year. Thus, the information brought before the local and general Institutions is much more widely circulated than it would otherwise be.

There is one important matter which has been brought to the notice of mining-engineers since the formation of the Institute, to which I think I shall draw special attention. That is, the discovery of the very important part that coal-dust, or in fact dust of other materials than coal, plays in causing explosions in our mines, and in increasing the disastrous effect of them.

In March, 1876, Mr. William Galloway read a paper before the Royal Society giving a set of experiments which he had made on the subject. This, I think, was the commencement of investi-

gations into the subject in Great Britain, although it had previous to that time been under the consideration of some French engineers. The result of Mr. Galloway's experiments went to shew that when a small percentage of gas was mixed with air, from 1 to 1½ per cent., so small as could not readily be detected and the air mixed with dust, when exposed to a sufficiently large volume of flame such as that from a blown-out shot, an explosion of a very violent character took place. After this, many experiments were made on the matter by members of this Institute, notably those made at Elswick colliery by Mr. W. Cochrane, forming the basis of a paper read on November 2nd, 1878, by Messrs. A. Freire Marreco and D. P. Morrison recording the results of these and other experiments made by them, and pointing out that certain descriptions of dust when mixed with air entirely free from gas and exposed to a flash of flame, produced an explosion. The discovery of this new source of danger explained the cause of many explosions which at the time they took place were quite inexplicable, although the greatest ability and perseverance had been exercised to discover the cause. Since attention had been called to the matter, many stringent rules have been put in force, to be observed in dry and dusty mines, and it is satisfactory to know that very few explosions are now caused from this source of danger.

In making this short, and, possibly, very imperfect review of the objects aimed at and the work done by this Institute during the last 50 years, it is incumbent on me to refer to the great part that it took in the establishment of the Durham College of Science.

Although the formation of such a College was not specifically referred to as one of the objects of the formation of the Institute yet it was laid down that one of the first principles of the Institute should be to raise the mining profession to a higher standard of intelligence in literature and science, and this could hardly be done without the establishment of a College of Science. Consequently, within a year of the formation of the Institute, namely, April 1st, 1853, the President, Mr. Nicholas Wood, referred to the subject of the establishment of a School or College of Mines. A Committee of the Institute had previously been appointed in furtherance of the object, and he stated the result of his interview with Dr. Lyon Playfair, the Warden of the University of

Durham, a Committee of the Corporation of Newcastle, representatives of the coal-trade, lead-mining, and manufacturers of the district, and informed the Council that he had the pleasing duty to report to them that considerable progress had been made in discussing the plans and in arranging the general outline of the scheme.

On December 7th, 1854, the Council of the Institute was formed into a Committee to draw up a plan in detail of a Mining College giving the scheme or system of education to be pursued. This report was widely circulated and gave the matter a practical bearing which it had not hitherto attained, and had the result of bringing, on January 11th, 1856, from the then Duke of Northumberland, a munificent offer to contribute £5,000 if £15,000 could be raised for the endowment, or £10,000 if £30,000 could be raised. The Council took steps to make this offer generally known and used every endeavour to raise the necessary funds, but they were not very successful. They, however, did not allow the matter to drop, but continued their negotiations chiefly with the Warden and Senate of the University of Durham. The proceedings of the Institute shew how indefatigable were their endeavours year after year to overcome all obstacles and prejudices which presented themselves to the formation of the scheme. It was not, however, until July 5th, 1871, that the Council of the Institute were able to report that a scheme had been finally agreed upon. This was largely due to the very great assistance rendered by the late Dean Lake and by the large grant of money given by the University of Durham. Thus the present Durham College of Science was founded on October 24th, 1871, jointly by the University of Durham and the North of England Institute of Mining and Mechanical Engineers, and from that day to this it has continued to prosper in a most satisfactory manner, and is now one of the finest colleges of physical science in the United Kingdom. There are at present 490 students attending the regular courses of lectures, and in addition to these there are 1,170 students attending the evening and special classes. Surely this large attendance shews the great need that existed for such an Institution, and the great work which it is now doing, not only in the education of those connected with mining but of those who are employed and likely to be employed in the manufactories of this great commercial district.

I think I may now investigate whether since the formation of this Institute and the founding of the Durham College of Science there has been any reduction in the great loss of life which was previously taking place in our mines. I do not for a moment wish to infer that the reduction in the loss of life which, as I hope to shew, has taken place, is due to the proceedings of this Institute; but I do claim for it that it has most materially assisted in the education of its members and the elevation of the science and art of mining, and that this has been one, if not the chief, agency by which the better and safer working of our mines is being carried on.

On reference to the *Mineral Statistics* of the United Kingdom it will be seen how enormously the coal-trade has increased during the past 50 years.

In 1851, the year immediately preceding that in which this Institute was formed, the output of coal for the United Kingdom was 53,000,000 tons, whereas in 1900—50 years after—the output had reached the very large figure of 225,170,163 tons, or more than four-fold. Of course, this enormous increase could not be obtained without employing a very much larger number of persons than were employed in 1851. The number of persons employed underground at that date was 171,893 whereas in 1900 they amounted to 644,242, or an increase of 3·74 times the number employed 50 years ago.

Consequently, mining-engineers have at the present day to provide for the daily safety underground of at least 472,349 more men and boys than they had to do in 1851. The men employed on the surface have increased in almost the same proportion. In 1851, there were 44,324 employed and in 1900 there were 174,275 or 3·83 times as many. Such has been the great increase in the coal-mining industry since this Institute was formed.

The chief object, however, in the formation of this Institute was the prevention of accidents, and the saving of loss of life.

In reviewing the results which have taken place, I think that it will show more accurately what has been done in this way if I take an average of 5 years at the commencement of the period under review and a 5 years' average at the present time, rather than take the first year and last year only. I will, therefore, take the result of the average of the years 1851 to 1855, and compare them with the average of the years 1896 to 1900 inclusive.

To have obtained a correct comparison of 50 years I ought to have taken a period of 5 years from 1847 to 1851 inclusive, to compare with 1896 to 1900, but previous to 1851 no reliable statistics were kept of accidents and deaths. I have, therefore, taken the period of 1851 to 1855.

At this early date, as perhaps at the present time, explosions in mines were always looked upon as being the cause of loss of life which should be the first and great object of the mining-engineer to prevent, although at that time as at the present, they were by no means the source of accidents which caused the greatest number of deaths.

The number of deaths which were caused by explosions on the average of 5 years from 1851 to 1855 was 231 per annum, whereas the average for the last 5 years was 64; but if we take into consideration the difference in the number of persons employed underground during the latter period, as compared with that employed during the first period, and if the same death-rate per person employed which was taking place in the first period had continued the same in the latter period from 1896 to 1900 there would have been 765 lives lost from this cause, or 701 more than actually took place.

The next class of accidents in mines is that produced from falls of roof and sides. In the first period under review, there was an average of 368 deaths per annum from this cause, whereas the average per annum during the latter period from 1896 to 1900 was 469, but if the same death-rate had continued during the latter period as was taking place in the first period there would have been 1,205 lives lost, thus shewing a saving of 736 lives per annum.

The next class of accidents are those which occur in and about shafts. The average for the five years of 1851 to 1855 was 236 per annum, whereas in the present period they average 75; but if the same death-rate per person employed had continued during the latter period as in the first there would have been a loss of 775 lives, thus shewing a saving of 700 lives per annum. The death-rate of 75 per annum, although too high (and I should like to see it reduced), does not seem excessive when it is taken into consideration that some 600,000 persons descend and ascend the shafts of our mines some 230 times each year. This, I think, shews that great care is exercised by the management and also by the workmen themselves.

The other classes of accident such as those termed "miscellaneous," comprising all accidents other than those I have stated and also those which take place on the surface, follow much more nearly the ratio of persons employed.

The total loss of life from all sources, on the average of the five years from 1851 to 1855, was 985 per annum, whereas the average for the five years from 1896 to 1900 was 1,001 per annum or 16 more than in the first period, although there were 525,297 more men and boys employed in and about the mines; but if the same death-rate had continued during the latter period as during the first, there would have been a loss of 3,146 lives instead of 1,001, thus shewing a reduction of 2,146 deaths.

I therefore venture to assert that the objects which the founders of the Institute had with regard to the preventing of accidents and saving of life have been very largely fulfilled, but by no means fully accomplished.

We as an Institute must not, however, rest satisfied with the progress which has been made during the last 50 years, but must continue to the utmost our exertions to raise still further the standard of attainment in literature and science and in the art of mining among our mine-managers. There is still a great deal to be done towards the reduction of accidents, and the loss of life occasioned by them. Although the loss of life from explosions in 1900 was only 44, caused by 24 accidents, yet if we analyse the causes by which they occurred, we find that 20 out of the 24 were caused by naked lights, and some of these occurred through officials using naked lights instead of safety-lamps while making the statutory inspection of the working-places. Surely, there is great room for improvement in the discipline and care by which these mines are worked, and this, if exercised, would prevent many accidents taking place from this cause.

In the following year, 1901, we find that the proportion of accidents from this cause, namely, naked lights, is not so great, though it accounts still for a large proportion, namely 12 out of 21 accidents.

The number of explosions caused by shot-firing does not seem so large; there were only 2 in 1900, and 3 in 1901. Considering the vast number of shots fired every day, these must be considered small in number.

The class of accident which causes the most deaths is that due to falls of roof and sides. Accidents from this cause are not nearly so much under the control of the management as those arising from many other causes. The nature of the work of mining necessarily requires the workmen to be left for several hours of the day without supervision, during which time they must exercise their own judgment as to the safety of the roof and sides. It is, therefore, to the skill and care of the workmen themselves that we must look for the reduction in the number of deaths from this cause; yet I am of opinion that, with a sufficient supply of material for propping always within easy access of the workmen, explicit instructions for its use, strict discipline and better lights, the number of deaths from falls of roof and sides would be considerably reduced.

I trust, therefore, that the members of the Institute will take this matter into their consideration and by united conference be able to devise means for the prevention of this class of accidents.

In a short address such as this, I have not considered it advisable to refer to the many other duties of the mining-engineer, although many are very important, yet not so important as that of the prevention of accidents. The economical working of our mines is, however, a very important matter, and affords ample scope for the communication of papers on the very various matters which affect the proper working of our collieries, so as to enable us to compete with other countries in the sale of the product of our mines.

In conclusion, I can only say that I hope that the good work which has hitherto been done by this Institution will continue, and that the results will in future be even greater than those which have been accomplished during the first 50 years of its existence.

Mr. John Daglish said that, as the oldest surviving Past-President and as one of the original members of fifty years ago, he had pleasure in moving a vote of thanks to Sir Lindsay Wood for his admirable address. He had had a very long professional connection with the President, and also with his father, the late Mr. Nicholas Wood, with whom he commenced his professional

career, and with whom he was associated for very many years. He congratulated Sir Lindsay Wood on his re-election to so important an office, and he was also glad to congratulate the Institute upon Sir Lindsay's accepting for the second period a position for which he was so highly fitted.

Mr. J. G. WEEKS (Retiring-President), in seconding the vote of thanks, said that the members felt highly gratified in having Sir Lindsay Wood—a distinguished son of their first president—to preside over the Institute. They were equally gratified in hearing from him so able and excellent an address, in which he had shown how the aims of the founders of the Institute had been amply fulfilled.

The vote of thanks was carried with enthusiasm, and was briefly acknowledged by Sir Lindsay Wood.

A conversazione was afterwards held, at the invitation of the President, in the Hancock Museum of the Natural History Society of Northumberland and Durham.

THE MUSEUM OF THE NATURAL HISTORY SOCIETY OF NORTHUMBERLAND AND DURHAM.

The following notes indicate the portions of the museum collections, which are likely to prove most interesting to geologists and mining-engineers.

The fossil-room, the third large room from the entrance, contains sets of fossils, which represent the life on the earth from the earliest period (Cambrian) of which any such record has been discovered. The contents of this room have been arranged in their present form comparatively recently, and are not yet finally labelled and mounted. Much of the case-room on the ground-floor is devoted to the Coal-measures and the Permian formation. Especially noteworthy are the fine series of Magnesian Limestone fossils collected by the late Mr. J. W. Kirkby and others; the Atthey collection of Coal-measure fishes and amphibians from the shales above the Low Main seam at Newsham; and the Hutton collection of Coal-measure plants. The Hutton collection con-

tains many of the original specimens figured in Messrs. Lindley and Hutton's *Fossil Flora of Great Britain* (1831-1837), a classical work which forms the basis of the modern knowledge and nomenclature of fossil botany. The collection was formerly the property of the North of England Institute of Mining and Mechanical Engineers, and was presented by them to the Natural History Society.

In the upper and lower western corridors will be found the collection of minerals, and in the wall-cases on the upper floor a series of rocks, the latter, so far, only roughly arranged. Amongst the rocks is a good set of the remarkable concretionary Magnesian Limestones of the Sunderland district.

In the lower eastern corridor, which contains objects too large to be placed in their proper systematic position, are some specimens of interest to practical geologists: for example, a section of the Brockwell seam, Coal-measure tree-stems, and some large polished slabs of Weardale " marbles " (Carboniferous Limestone crowded with corals).

Of the remainder of the Museum collections, the sections of chief general interest include the well-known Hancock collection of British birds occupying the central room, the gallery of woodcuts and original drawings by Thomas Bewick, and the upper eastern corridor containing the ethnology collection.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,
HELD AT MATLOCK BATH, AUGUST 30TH, 1902.

MR. G. E. COKE, RETIRING-PRESIDENT, IN THE CHAIR.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1901-1902.

The following is a comparative summary of the number of members and the state of the finances for the last three years:—

	Year 1899-1900.	Year 1900-1901.	Year 1901-1902.
Honorary Members ...	14	14	15
Life Members ...	8	8	8
Members ...	237	244	252
Associate Members	5	5	4
Associates ...	59	64	65
Students ...	28	33	31
Totals ...	351	368	375

	£ s. d.	£ s. d.	£ s. d.
Cash Receipts ...	493 17 6	505 6 7	535 1 0
Cash Payments ...	425 1 7	474 18 4	467 4 7
Bank Balance ...	73 18 2	104 6 5	172 2 10
Invested Fund	640 0 0	640 0 0	640 0 0
Totals ...	£713 18 2	£744 6 5	£812 2 10

The following table shows the alteration in membership of the various classes during the past twelve months. The Council regret that they have had again to strike off a considerable number of members, in consequence of the non-payment of subscriptions for a period of three years, and this accounts to a very great extent for the resignations shown below. A large number

of subscriptions still remains unpaid, in spite of repeated reminders, and the Council make a special request for their payment.

		Less			Add		
	1900-1901.	Dead.	Resigned.	Transferred.	Elected.	Transferred.	1901-1902.
Hon. Members	14	3	—	—	3	1	15
Life Members	8	—	—	—	—	—	8
Members ...	243	1	4	1	10	5	252
Associate Members	5	—	1	—	—	—	4
Associates ...	64	—	5	—	5	1	65
Students ...	33	—	1	6	5	—	31
Totals ...	367						375

The Council wish to place upon record their regret at the deaths of Messrs. Alfred Barnes and J. E. F. Chambers, the former being a Past-President, and both having rendered great services to the Institution in former years.

The working of the Institution from a financial point of view may again be considered satisfactory, and the bank-balance has been increased from £104 6s. 5d. to £172 2s. 10d.

The annual meeting of The Institution of Mining Engineers was held in Glasgow in September, 1901, when a large number of members attended, in view of the Exhibition which was then open. The London meeting was held in May, 1902.

Local meetings were held on August 14th, 1901, when the excursion included a visit to Belvoir Castle, and the ironstone-mines of the neighbourhood; on September 19th, 1901, this being a joint meeting of the members of this Institution and the Midland Institute of Mining, Civil and Mechanical Engineers at Altofts colliery; on December 7th, 1901, at Derby; on March 8th, 1902, at Nottingham, when an excursion was organized to visit the sinking at Gedling; and on June 14th, 1902, a joint meeting of this Institution and the Midland Institute of Mining, Civil and Mechanical Engineers at Sheffield.

The Council wish to take this opportunity of thanking the firms and gentlemen who have been good enough to entertain hospitably the members of this Institution from time to time, and to throw open their works for inspection.

The following papers have been contributed to the *Transactions* by members of the Institution, since the last Report of the Council:—

"The Grubb Sight for Surveying-instruments." By Sir Howard Grubb and Mr. Henry Davis.
"Changing Headgears at Pleasley Colliery." By Mr. G. A. Longden.
"The Belvoir Iron-ore." By Mr. R. F. Percy.

The Library has now been placed in Nottingham University College, and the catalogue has been printed and circulated among the members.

An index to the seventeen volumes of the *Transactions* of the Chesterfield and Derbyshire Institution has been printed, and can be obtained from the Secretary.

The CHAIRMAN (Mr. G. E. COKE) moved the adoption of the report and the statement of accounts.

Mr. W. B. M. JACKSON seconded the motion, which was adopted.

The SECRETARY announced the election of the following gentlemen:—

HONORARY MEMBERS—

Mr. F. A. GRAY, H.M. Inspector of Mines, 7, Victoria Square, Penarth, Cardiff.

Mr. R. MCLAREN, H.M. Inspector of Mines, Edinburgh.

Mr. W. H. PICKERING, H.M. Inspector of Mines, Doncaster.

MEMBERS—

Mr. FRANK ARTHUR BLACKBURNE, Colliery Manager, North Wingfield, Chesterfield.

Mr. WALTER GERARD BOULTON, Mining Engineer, Crookhaven, County Cork.

Mr. STANLEY CLAY, Mining Engineer, Wassau Gold-mining Company, London.

Mr. ROBERT HOOD HAGGIE, Electrical Engineer, 69, Rose Hill Street, Derby.

Mr. RALEIGH HILLS, Electrical Engineer, Hill Top Farm, Tupton, Chesterfield.

Mr. JAMES MCGOWAN, Civil and Mining Engineer, Waterworks Offices, Nottingham.

Mr. JOHN WILLIAM FRYAR, Mining Engineer, Sherwood Colliery, Mansfield.

ASSOCIATE MEMBERS—

His GRACE THE DUKE OF RUTLAND, K.G., Belvoir Castle, Grantham.

His GRACE THE DUKE OF PORTLAND, K.G., Welbeck Abbey, Worksop.

THE RIGHT HON. THE EARL MANVERS, Thoresby Park, Ollerton, Notts.

Major REGINALD PEMBERTON LEACH (late R.A.), Nethermoor, Tibshelf.

ASSOCIATES—

Mr. GWYN HARRISON COATES, Manager's Assistant, Tenter Hill, Hucknall Torkard.

Mr. SAMUEL FIELD, Deputy, 27, Station Street, East Kirkby, Notts.

STUDENT—

Mr. HAROLD SHAW, Mining Pupil, 34, Colville Street, Nottingham.

Dr. THE TREASURER IN ACCOUNT

	£ s. d.	£ s. d.
251 Members as per List, 1901-1902, of whom 8 are Life Members		
243 Members at £1 11s. 6d.	382 14 6	
Less 3 paid in advance, 1 transferred, 1 deceased, and 5 resigned, of whom 3 should have paid ...	11 0 6	
		371 14 0
9 Members paid in advance, 1902-1903		14 3 6
1 Member rejoined		1 11 6
5 Associate Members as per List	7 17 6	
1 *Less* resigned	1 11 6	
4		6 6 0
97 Associates and Students, as per List	97 0 0	
8 *Less*, 7 resigned, of whom 5 should have paid, and 1 paid in advance	3 0 0	
89		94 0 0
5 Students to pay difference as Members		2 17 6
5 Students to pay Transfer Fees		2 12 6
10 New Members and Entrance Fees		26 5 0
10 New Associates and Students		10 0 0
4 Associates paid in advance, 1902-1903		4 0 0
The Butterley Company		5 5 0
		£538 15 0
Arrears, as per last Balance-sheet	84 0 6	
Add Arrears not in last Balance-sheet	4 14 6	
	88 15 0	
Deduct irrecoverable	29 3 6	
		59 11 6

Examined and found correct, August 11th, 1902.

JOHN HALL,
JOHNSON PEARSON, } Auditors.

	£598 6 6

WITH SUBSCRIPTIONS, 1901-1902. Cr.

	Unpaid. £ s. d.	Paid. £ s. d.
196 Members at £1 11s. 6d.		308 14 0
1 Member transferred		
1 Member deceased		
3 Members paid in advance		
5 Members resigned, 3 unpaid	4 14 6	
36 Members unpaid	56 14 0	
1 Member part paid	0 1 6	1 10 0
243		
9 Members paid in advance		14 3 6
1 Member rejoined		1 11 6
3 Associate Members		4 14 6
1 Associate Member, unpaid	1 11 6	
4		
61 Associates and Students		61 0 0
5 Associates and Students resigned, unpaid	5 0 0	
1 Student paid in advance		
4 Students transferred		4 0 0
24 Students unpaid	24 0 0	
89		
4 Students paid difference as Members		2 6 0
1 Student not paid difference as a Member	0 11 6	
4 Students paid Transfer Fees		2 2 0
1 Student not paid Transfer Fees	0 10 6	
10 New Members and Entrance Fees		26 5 0
10 New Associates and Students		10 0 0
4 Associates paid in advance		4 0 0
The Butterley Company		5 5 0
	93 3 6	445 11 6
Arrears	52 14 0	36 1 0
	145 17 6	
Deduct irrecoverable	29 3 6	116 14 0
		£598 6 6

Abstract of Accounts for Year ending July 31st, 1902.

Receipts.

	£	s.	d.
Balance brought forward	104	6	5
196 Members at £1 11s. 6d.	308	14	0
4 Members transferred from Students	6	6	0
1 Member re-joined	1	11	6
1 Member paid portion	1	10	0
1 Member paid twice, in error	1	11	6
3 Associate Members	4	14	6
61 Associates and Students	61	0	0
1 Subscribing Firm—The Butterley Company	5	5	0
9 New Members and Entrance Fees	23	12	6
10 New Associates and Students	10	0	0
4 Transfer Fees—Students to Members	2	2	0
Arrears of Subscriptions	38	13	6
Sale of *Transactions*	28	17	6
Sale of Indices to *Transactions*	2	17	6
Excerpts from *Transactions*	1	5	2
Subscriptions, paid in advance	18	3	6
Midland Railway Debenture interest	15	1	0
Bank interest	3	15	10
	£639	7	5

Examined and found correct, August 11th, 1902.

John Hall, Johnson Pearson, } Auditors.

Expenditure.

	£	s.	d.	£	s.	d.
The Institution of Mining Engineers:—						
Call 1901-02 (Vols. xxii. and xxiii.)	285	0	0			
,, 1900-1901 (Vols. xx. and xxi.)	15	4	0			
Arrears	13	0	0			
				313	4	0
Exchanges, excerpts, etc.				4	11	10
Printing and stationery				32	19	4
Auditors				3	3	0
Reporting proceedings				7	14	3
Subscription returned				1	11	6
Postages, parcels, etc.				14	9	11
Travelling and miscellaneous expenses				8	12	6
Fees at meetings				1	2	6
Secretary's salary, assistance, and use of office				75	0	0
Rent of room for storing *Transactions*				2	10	0
Expenses of joint meeting				1	10	0
Bank commission				0	13	3
Cheque book				0	2	6
Balance in bank				172	2	10
				£639	7	5

ELECTION OF OFFICERS, 1902-1903.

The report of the Scrutineers (Messrs. L. W. de Grave and C. R. Sams) was read as follows:—

President:

Mr. G. Elmsley Coke.

Vice-Presidents:

Mr. G. J. Binns.	Mr. W. B. M. Jackson.	Mr. G. Spencer.
Mr. A. S. Douglas.	Mr. E. Lindley.	Mr. J. T. Todd.

Councillors:

Mr. G. S. Bragge.	Mr. C. R. Hewitt.	Mr. C. Sebastian Smith.
Mr. J. W. Eardley.	Mr. H. R. Hewitt.	Mr. E. D. Spencer.
Mr. G. C. Fowler.	Mr. T. G. Lees.	Mr. H. Walters.
Mr. W. H. Hepplewhite.	Mr. J. Piggford.	Mr. W. Wilde.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1902-1903.

Mr. G. J. Binns.	Mr. M. Deacon.	Mr. W. B. M. Jackson.
Mr. G. Elmsley Coke.	Mr. H. R. Hewitt.	Mr. G. A. Lewis.
	Mr. E. Lindley.	

A cordial vote of thanks was accorded to the Scrutineers for their services.

The members proceeded in brakes to the Mill Close lead-mine, and by permission of Mr. A. M. Alsop, they were allowed to view the underground workings of the mine, and also to inspect the system of separating the lead from impurities.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, JULY 25TH, 1902.

MR. JOHN GERRARD, RETIRING-PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Mr. C. C. Ellison and Mr. Thos. Holliday were appointed scrutineers of the balloting-papers for the election of officers, and also for representatives on the Council of The Institution of Mining Engineers for 1902-1903.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. HUBERT ORMOND BISHOP, Assistant Colliery Manager, Tinsley Park Collieries, Sheffield.

Mr. SQUIRE BROADBENT, Colliery Manager, Ossett, Wakefield.

Mr. JOHN WM. HALMSHAW, Assistant Colliery Manager, Kelvin Grove, Wombwell, Barnsley.

Mr. TOM HARGREAVES, Colliery Manager, Newton Villa, Chapel Allerton, Leeds.

STUDENT—

Mr. HAROLD T. FOSTER, Mining Pupil, Howsley Villas, Chapeltown, Sheffield.

The Annual Report of the Council, and the statement of accounts for the past year were read as follows:—

THE COUNCIL'S ANNUAL REPORT.

The Council have pleasure in presenting to the members of the Institute their report on the work of the past year.

The numbers of members for the past two years are as follows:

Years.	1900-1901.	1901-1902.
Life Members	3	1
Members	237	255
Associate Members	8	10
Associates	13	13
Students	11	11
Totals	272	290

From this table, it will be seen that the membership has increased by 18 during the past year, which is very satisfactory.

The Council regret to have to state again that there has been during the year some irregularity in the payment of subscriptions, the arrears now amounting to £24, due from 16 members. Of the £33 arrears of subscriptions due for 1900-1901, £12 have been collected during the past year.

There is a balance in the bank of £180 15s. 2d., against £132 4s. 2d. at the end of the previous year, and all debts have been paid.

The following papers have been read during the year:—

"An Apparatus for Lighting Miners' Safety or other Enclosed Lamps by Electric Current." By Mr. Edward Brown.
"The B.C.B. Instantaneous Either-side Brake for Railway-wagons or Similar Vehicles." By Mr. Edward Brown.
"Coal-mining in India." By Mr. Robert Clarke.
"An Instrument for the Automatic Record of Winding-operations." By Mr. W. N. Drew.
"The Application of Coal-cutting Machines to Deep Mining." By Mr. W. E. Garforth.
"The Kitson System of Petroleum Incandescent Light." By Mr. Arthur Kitson.
"Chinese Mines and Miners." By Mr. Alexander Reid.
"The Craig Coal-washer." By Mr. William Scott.

The Council regret to record the loss, through death, of Mr. F. N. Wardell, the late esteemed inspector of mines for Yorkshire.

The scheme for the proposed Benevolent Fund of the Institution of Mining Engineers has fallen through, as there was not sufficient support given to enable it to be a success. The Council of The Institution of Mining Engineers are dealing with such

amounts as have been paid, in a manner which appeared satisfactory to the representatives of the Institutes at the meeting held in London.

The Council wish to record their great appreciation of the care and skill displayed by Mr. Garforth in providing an experimental gallery for the purpose of testing apparatus for life-saving in collieries, and the opportunity given to members of this Institute to test the same.

The prize for the best paper read before the Institute has been awarded to Mr. W. E. Garforth for his admirable paper on "The Application of Coal-cutting Machines to Deep Mining."

With a view to increasing the intercourse between those directly interested in the coal-fields of Yorkshire, Nottinghamshire and Derbyshire, the Presidents of the Midland Counties Institution of Engineers and of this Institute held a Joint Meeting of the two Councils, when it was resolved that a committee should be appointed to arrange for Joint Meetings of the two Institutes.

The Council have appointed a Committee to collect from members, and from others, who are willing to give the information, detailed sections of the strata bored and sunk through at the various collieries in Yorkshire, Nottinghamshire and Derbyshire, with a view of having them tabulated and printed in a suitable volume in the same way as has been done by the North of England Institute of Mining and Mechanical Engineers, and when completed, of issuing a copy to each member. The Committee would be obliged for any assistance that the members can give them in this work.

The Council suggest that an excursion should be arranged to visit the Düsseldorf Exhibition and some of the most interesting German collieries. The excursion will take place on or about September 5th, for a week or ten days, and will also be open to the members of the Midland Counties Institution of Engineers.

The report and accounts were unanimously approved.

Dr. THE TREASURER (MR. T. W. H. MITCHELL) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS, 1901–1902. Cr.

	£ s. d.	£ s. d.
July 1st, 1901.		
To Balance at Bankers	132 4 2	
„ Cash in Treasurer's hands	4 11 2	
		136 15 4
June 30th, 1902.		
To Subscriptions for 1901-1902, 280 at £1 10s.	420 0 0	
„ Subscriptions paid in advance for 1902–1903, 5 at £1 10s.	7 10 0	
„ Arrears, 1899-1900, 2 at £1 10s. ...	3 0 0	
„ 1900-1901, 9 at £1 10s. ...	13 10 0	
		444 0 0
„ Sale of dinner tickets	12 15 0	
„ Members' portion of the wine-account	2 8 9	
		15 3 9
„ Letting of room		1 7 6
„ Sales of *Transactions* and authors' copies of papers		0 13 3
„ Bank interest		6 12 11
		£604 12 9

Examined and found correct,
J. L. MARSHALL,
M. H. HABERSHON,
AUDITORS.

July 10th, 1902.

	£ s. d.	£ s. d.
June 30th, 1902.		
By The Institution of Mining Engineers:—		
Call of 19s. per Member on 290 Members	275 10 0	
Balance of call for 1899-1900 ...	2 0 0	
„ „ 1900-1901 ...	9 10 0	
Excerpt *Transactions*, etc.	4 1 9	
Proportion of cost of exchanging *Transactions* with other societies ...	3 6 8	
		294 8 5
„ Annual dinner		18 8 0
„ Printing and stationery		11 13 0
„ Rent of room		12 0 0
„ Reporter		9 10 0
„ Insurance		1 11 6
„ Cleaning		0 10 0
„ Electric light		0 1 1
„ Hire of rooms for meetings in Wakefield, Sheffield, Barnsley and Leeds		3 11 6
„ Secretary's salary	£50 0 0	
„ „ expenses	6 15 6	
		56 15 6
„ Stamps, telegrams, carriage, wrappers and sundries		14 5 0
„ Balance at Bankers	£180 15 2	
„ Cash in Treasurer's hands	1 3 7	
		181 18 9
		£604 12 9

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.
GENERAL STATEMENT, 1901-1902.

LIABILITIES.

1902.		£ s. d.
June 30th.—None.		
„	To Balance, being capital	538 1 9
		£538 1 9

Examined and found correct,
J. L. MARSHALL,
M. H. HABERSHON,
July 10th, 1902. AUDITORS.

ASSETS.

1902.		£ s. d.	£ s. d.
June 30.—By	Cash in Bank	180 15 2	
„ „	„ Treasurer's hands ...	1 3 7	
			181 18 9
„ „	Value of 6,844 parts of *Transactions*, at 1s. ...	342 4 0	
„ „	Value of 115 copies of Narratives of Sudden Outbursts of Gas, at 1s.	5 15 0	
„ „	Value of 116 copies of Committee's Report on Safety-lamps, at 1s.	5 16 0	
„ „	Value of 16 copies of Report of French Commission on Use of Explosives, at 3s. ...	2 8 0	
			356 3 0
			£538 1 9

ELECTION OF OFFICERS FOR 1902-1903.

The SCRUTINEERS reported the result of the election, as follows:—

PRESIDENT:

Mr. H. B. NASH.

VICE-PRESIDENTS:

Mr. J. E. CHAMBERS. | Mr. WALTER HARGREAVES. | Mr. J. R. ROBINSON WILSON.

COUNCILLORS.

Mr. E. BROWNE.	Mr. I. HODGES.	Mr. R. ROUTLEDGE.
Mr. H. ST. JOHN DURNFORD.	Mr. R. H. LONGBOTHAM.	Mr. CHARLES SNOW.
Mr. P. C. GREAVES.	Mr. J. L. MARSHALL.	Mr. W. WASHINGTON.
Mr. M. H. HABERSHON.	Mr. W. H. PICKERING.	Mr. WILLIAM WILDE.

Mr. JOHN GERRARD (retiring President), in vacating the chair, regretted that the period, to which he looked forward two years ago, was now ended. It had been to him a great honour to be elected President, and he appreciated it very highly. He expressed his gratitude for the cheerful goodwill shown towards him by the members, and to the Secretary (Mr. T. W. H. Mitchell) for his valuable assistance. He had pleasure in introducing Mr. Nash, who would, he was sure, receive the same hearty support that he had done; and heartily congratulated Mr. Nash on having attained to that distinction, and wished him a successful term of office.

The PRESIDENT (Mr. H. B. Nash) said that he appreciated the honour conferred upon him by his election as President of the Institute. He considered it an honour to have the confidence of the members; and he hoped that his health would permit him to follow in the footsteps of his predecessors. He hoped that the interest which he had always taken in the success of the Institute would continue to grow, and that the good work done in the past would not stop through his occupancy of the chair.

Mr. W. E. GARFORTH moved a vote of thanks to Mr. John Gerrard for the able way in which he had conducted the proceedings of the Institute during his two years of office. The members would agree that, from the time Mr. Gerrard read his presidential address, he had in every possible way helped the work of the Institute, and was entitled to their best thanks.

Mr. J. Nevin, in seconding the vote of thanks, said that Mr. Gerrard had been one of the most active members of the Institute almost from its formation; and, although he had gone into Lancashire, he still maintained his interest in their Institute. The members would agree that the two years of Mr. Gerrard's presidency were among the most successful years of the Midland Institute of Mining, Civil and Mechanical Engineers.

The vote of thanks was cordially approved.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1902-1903.

The Scrutineers reported that the following gentlemen had been elected:—

Mr. W. H. Chambers.
Mr. W. E. Garforth.
Mr. J. Gerrard.
Mr. H. B. Nash.
Mr. J. Nevin.
Mr. W. H. Pickering.
Mr. G. Blake Walker.

Mr. W. H. Pickering (H.M. Inspector of Mines) read the following "Notes on Systematic Timbering":—

NOTES ON SYSTEMATIC TIMBERING.

BY W. H. PICKERING.

This paper is not written in a didactic spirit, but with the purpose of raising a discussion upon a subject which, in the writer's opinion, has never received the attention it deserves.

Since the year 1868, no less than 1,640 lives have been lost in Yorkshire from falls of roof and sides, or an average annual loss of 48 lives. The average for the past 10 years has been 45, and during the same period the average annual loss in the United Kingdom has been 446; and, in 1901, 482 lives were lost. It must be remembered that the injured who linger more than a year and then die, are not included.

The writer is trying to collect statistics of such accidents in this district, and has already gathered enough to show that they are surprisingly numerous.

Satisfactory statistics of the number of non-fatal accidents are not available, as the Coal-mines Regulation Act gives no definition of a "serious accident," and opinions on the subject differ widely; but, during 1900, 1,682 persons were returned as being seriously injured by falls of roof and side, and the number for last year was 1,583. Many of these persons are crippled for life.

The 482 lives lost during 1901, from falls of roof and side, are classified in Table I.

During the last decade, the death-rate from falls has remained practically stationary. Such facts and figures should make even the most careless person pause, and reflect as to whether the right methods of getting coal are being practised. If the total of accidents from falls were accumulated by monthly or quarterly catastrophes, the public conscience would have been shocked long ago and probably drastic remedies would have initiated. But as the accidents claim one or two victims daily, the attrition of life passes almost unnoticed.

Safety of life and limb must always be the first consideration, but the economic point of view must not be overlooked. Every life sacrificed is a direct and serious loss to the country, and every fall is an obstruction and an expense in the mine. Such is the crying evil: what is the remedy?

TABLE I.—NUMBER OF ACCIDENTS AND DEATHS FROM FALLS OF ROOF AND SIDE DURING 1901 IN THE UNITED KINGDOM.

Name of Mines-inspection District.	At the Working face.		On Roads, while repairing or enlarging.		On Roads, while otherwise working or passing.		TOTALS.	
	No. of Fatal Accidents.	No. of Deaths.	No. of Fatal Accidents.	No of Deaths.	No. of Fatal Accidents.	No. of Deaths.	No. of Fatal Accidents.	No. of Deaths.
East Scotland ..	29	32	4	4	3	4	36	40
West Scotland ...	26	26	2	2	3	3	31	31
N'castle-on-Tyne	28	32	4	4	5	5	37	41
Durham	30	30	6	6	3	3	39	39
Yorkshire ...	30	30	10	10	7	8	47	48
Manchester ...	22	23	9	10	6	6	37	39
Liverpool... ..	25	25	14	15	7	7	46	47
Midland ...	23	24	8	9	7	7	38	40
Staffordshire ...	32	32	10	14	4	4	46	50
Cardiff ...	12	12	11	11	4	4	27	27
Swansea	27	30	9	9	13	14	49	53
Southern	20	20	5	5	2	2	27	27
TOTALS ...	304	316	92	99	64	67	460	482

It would pass the wit of man to prevent some of these accidents, but, in the opinion of the writer, the total would be very considerably reduced, and at the same time the mines could be more economically worked and with less loss of coal, if systematic methods of work and systematic timbering were the general rule instead of the exception. The magic of method will work miracles. The difficulties of changing the method of working in any colliery are enormous, for the officials and the workmen have absorbed the wrong idea, and often work a radically wrong method with astonishing success, but with undue risk and an unnecessarily high cost per ton. It may take many years for a manager to educate his workmen and officials to a necessary change, but it is well for one to be a sower even if one does not live to reap the harvest.

A thoughtful paper read before the members by Mr. W. E. Garforth, and illustrated by photographs, has brought home to the minds of all who were present, the importance of working long-

wall faces in straight lines and at an angle with the cleat, when possible.

True longwall, that is, longwall in which the face is a straight line and is advanced in parallel slices, is the simplest and safest method of working coal, and there are few seams that do not lend themselves to it. But the direction of the working-face, the distances apart at which the gate-roads must be set out, the depth of the holing, and the thickness of the ripping, are vital points, which must be judiciously combined if the seam is to be worked to the best advantage. These points are too often settled haphazard, instead of receiving the anxious consideration that they merit. The object should be to distribute the "weight" evenly over a given area, so that the roof settles quietly; and the weight instead of being a master becomes a servant, helping to get the coal. True longwall work most readily lends itself to a thorough system of timbering.

Special timbering rules have now been established at most mines in the United Kingdom. The Special Rules regarding "timbering in mines" as first issued by the Home Office were as follows:—

(a.) *Propping of Roof.*—Where timber or other material is used to support the roof, the owner, agent or manager shall keep posted up, at the mine, a notice specifying for each seam, or district of a seam, the maximum distances apart at which props or other roof-supports at the working-faces are to be set; and the persons setting props or other roof-supports shall see that this maximum distance is not exceeded.

(b.) *Supply of Timber.*—Where the timbering of the working-places is done by the workmen employed therein, the miners shall have a sufficient supply of suitable timber such as is ordinarily used at or within 30 yards of every working-place where mineral is being gotten, and the deputy shall see that such supply is so kept there.

(c.) *Drawing Timber.*—Wherever timber has to be withdrawn from the waste or other disused parts of the mine, the prop-drawer shall have with him a ringer-and-chain, dog-and-chain, or other suitable appliance ready for use.

In most of the mines-inspection districts, the rules have been amplified and strengthened and have been dove-tailed into the code of Special Rules. In Yorkshire, they have been taken as they were issued, and placed at the end of the Special Rules as an addendum.

The duty of specifying by notice the maximum distances at which timber shall be set is variably interpreted. One manager

will be content with a meagre specification of distance, posted up with the Special Rules; while his neighbour will draw up a comprehensive system of rules for timbering, and post the notice in every working-place. It is surely desirable that the notice should not only comply with the letter of the rule, but that it should be so drawn as to give practical effect to the scheme of systematic timbering, which the manager should devise so as to suit the working of the mine under his charge, and to be a means of educating the officials and workmen. It is not easy to draft a model code, when we remember that seams worked in this country vary from 30 feet to 18 inches in thickness, but the following notice is suggested as embodying most of the vital points:—

Name of Colliery or Mine ....

Name of Seam ... .

In compliance with Special Rule......, the following system of timbering has been adopted for the above seam:—

(1.) The timbering of the working-places shall follow, as far as circumstances will admit, the plan of the system, which is posted up at the station.

(2.) The rows of props must be set parallel with the face, and the distances between the rows shall not exceed .....feet, and between the props shall not exceed......feet.

(3.) The props must be set off and on, as shown on the plan.

(4.) Every prop, not being under a bar, shall be capped with a lid not less than......feet long and of sufficient thickness.

(5.) As far as possible, all lids must be fixed so that the natural breaks and joints of the roof shall be crossed at right angles.

(6.) Holing sprags shall be set as soon as there is room, and shall not be placed more than......feet apart; and when the holing exceeds......feet deep a further row of sprags shall be set.

(7.) Where the coal is more than......feet thick or is overhanging, or lies at an angle, cockers or long sprags shall be set.

(8.) Bars shall be set at the way-ends, as shown on the plan, and shall not exceed......feet apart.

(9.) All timber must be fixed as soon as there is room, and, where necessary, fore-sets must be set.

(10.) Additional timber shall be set when and where required.

(11.) Pack-walls shall be carefully built, and pinned to the roof as soon as possible.

(12.) When drawing timber a workman shall use a ringer-and-chain, and other suitable tools.

(13.) Where necessary, catch-props and other temporary timber shall be set to keep the timber-drawer safe.

It is suggested that a copy of the preceding notice should be posted at the stations, and other convenient places in the pit, and where possible, in every working-place; and that it should be

given to each miner with the Special Rules. However good a system may have been devised by the manager, it is only by hammering it into the workmen and subordinate officials that it can be successful in practice. Even those who are unwilling to learn must be educated, though such a task is a thankless one. What is wanted is the formation of public opinion, not only among managers and officials, but also among the workmen, in favour of effective systems of working and timbering. The suggested plan should be on a large scale, and should show graphically the system of timbering.

Next in importance to systematic setting of timber, is the systematic and regular drawing and recovery. Props left straggling in the goaf prevent the roof from settling down quietly and regularly on the pack-walls, and are often the cause of sudden weights and bumps. All timber should be drawn by or under the direct personal supervision of skilled men, and a very liberal supply of proper timber-drawing appliances, such as ringers-and-chains and long-handled "bunters" and prickers should be provided in every district of the pit.

A manager must exercise all the skill and judgment with which nature has endowed him and which experience has strengthened, to devise a system of work and timbering which will best suit the seams that he has to work, and such methods will necessarily differ widely.

The following is not put forward as a model system suitable for most seams; but it is given as an instance of a system of timbering which allowed a seam to be economically worked under an exceedingly dangerous roof with almost perfect safety (Plate III.).

The seam is worked longwall, and the line of the working-face cuts across the cleat at an angle of about 30 degrees. The holing is made in a stratum of fire-clay, under the coal, and the bottom section of the seam is blocked down far enough to let the miners hole 4 feet deep, as the fire-clay is only 8 inches thick. The timber is set in ranks parallel with the face. The props are spaced 2½ feet apart, and the ranks are placed 4 feet from the face where the tubs pass, and 2½ feet from the face where the coal is being holed. There is a bar, 5 feet long, over each prop and the

ends of the bars are slotted into the coal. Sprags are set under the holed coal opposite every other prop and are thus spaced 5 feet apart. Where the coal is apt to flake off, cockers are set in addition to the sprags, and are also placed opposite each alternate prop. The cross-pieces of the cockers nearly meet, as they are 4½ feet long. As the holed coal is removed, the timber is set so as to follow up the work as closely as possible. When all the holed coal has been drawn, a fresh rank of timber is set 2¼ feet from the face, with the bars slotted into the coal ready for another holing. The pack-wall is built close to these, and the back timber is then drawn. The goaf is closely packed throughout, the entire length of the face.

The section of the seam is as follows:—

		Ft. In.	Ft. In.
Roof:	Shale, with bands of ironstone	—	—
Second Ripping:			
	Sandstone, soft	2 0	
First Ripping:			
	Shale, with bands of ironstone	1 6	
		——	3 6
Seam:	COAL, top	2 6	
	COAL, bottom	1 2	
		——	3 8
Holing:	Fire-clay	0 8	0 8

The height of the working-places was 4 feet 4 inches. The first ripping was kept close to the way-end, and the second ripping was 4 or 5 feet behind the first.

The sketches (Plate III.) were made from an actual working-face.

Mr. J. Gerrard (H.M. Inspector of Mines), in moving a vote of thanks to Mr. Pickering for his paper, said that the mention of the word "systematic" was a bogey to many mining-engineers. In the Yorkshire mines-inspection district, there were many men of many minds, and it was a distinct advantage to hear diverse views. There were scarcely two seams alike, and the same seams were found under different conditions in different parts, even in Yorkshire. Mr. Pickering advanced the opinion that the same system of timbering should not be applied to every seam, or to the

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Vol. XXIV, Plate III.

To illustrate Mr. W. H. Pickering's "Notes on Systematic Timbering"

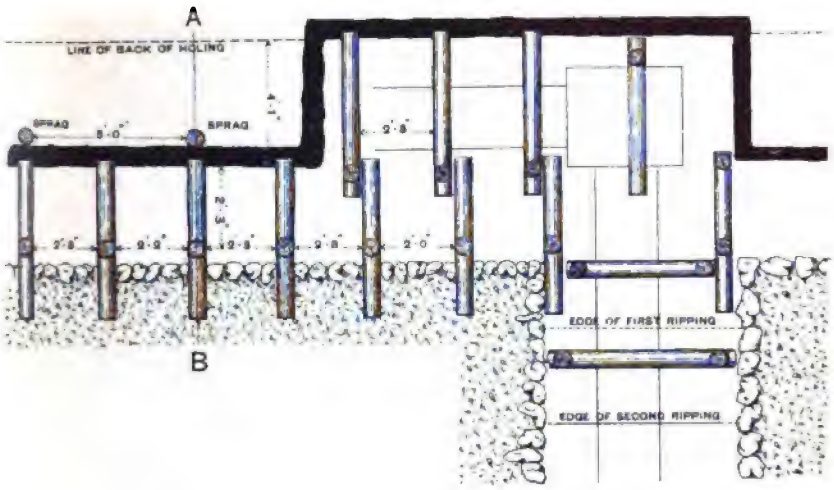

Fig. 1.—Sketch-plan of Working-face.

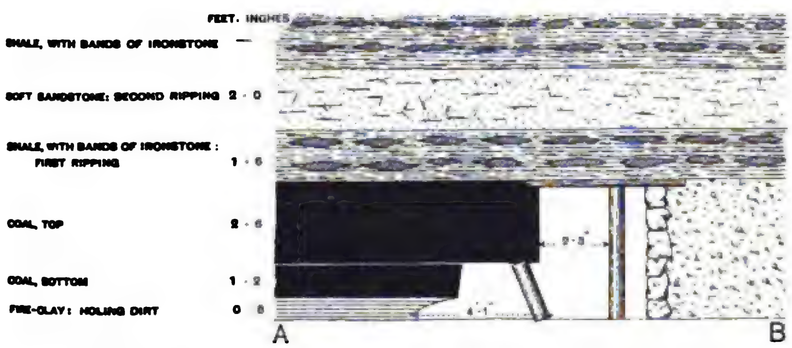

Fig 2.—Cross-section on Line A B of Fig. 1.

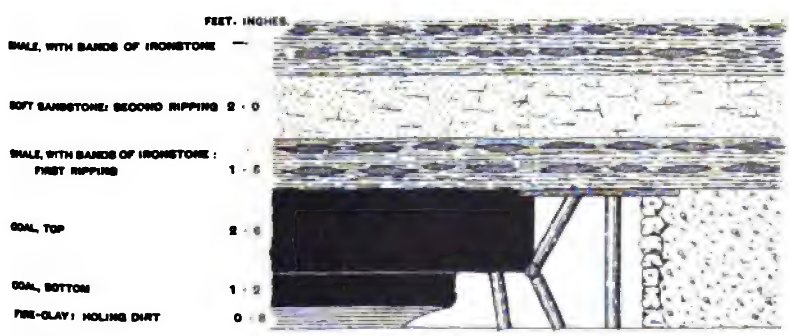

Fig. 3.—Cross-section, shewing Arrangement of Timber, where Cockers are used.

Scale, 6 Feet to 1 Inch.

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Vol XVI, Plate XV.

same seam throughout the Yorkshire district, and that in every seam there should be systematic rather than chance or haphazard timbering. The admirable old saying of having a place for everything and everything in its place was the first step towards system. This matter had been under consideration for some time, and the first step in the right direction was to prescribe by rule and by order a system of timbering in working-places, and the success of that first step entirely depended upon its enforcement. They might indicate the direction, but if they neglected to enforce it, then it were better that the step had not been made. Whether coal-cutting machinery would help the members to obtain a system of timbering would largely depend upon the conditions of the seam, and upon the perseverance and patience of those connected with its working; and from his experience, he was absolutely satisfied that no coal-cutting machine would work efficiently in every seam.

Mr. H. B. Nash, in seconding the vote of thanks, said that the members were indebted to Mr. Pickering for the admirable suggestions contained in his paper. In his experience, colliery-officials were always willing to carry out any suggestions to enhance safety that might be made to them; but they experienced the greatest difficulty in inducing the workmen to do the same. It should be impressed upon each man that the rules referred to him as an individual, and that by carrying them out he was helping to keep himself and his fellow-workmen safe. In nine cases out of ten, from their habitual contact with danger the collier never thought how an accident happened.

The resolution was cordially approved.

Mr. Arnold Lupton said that there could not be any doubt in the mind of anyone who had studied the statistics of mining accidents in this country, and who had seen how greatly the death-rate per ton raised had been reduced in the last 50 years, that the number of accidents might be reduced without drastic rules. Speaking on the subject of mining explosions, he could remember the time when every mining explosion was attributed to gas; but an enormous reduction in deaths from explosion resulted from the introduction of explosives, which did not produce so large a flame as gunpowder; and it took nearly 30 years to produce a general understanding on that great question. Now he found that some

mining-engineers and some of H.M. inspectors of mines were starting on what was at present the chief branch of our death-rate, the timbering of the working-places. He had read the papers and discussions on the subject, and he was very much impressed by the advantages of system in timbering; and he thought that the system introduced by Mr. Fowler at the Babbington collieries had many advantages. He was always prepared to consider a subject thoroughly, whatever the subject might be that he took in hand; and if managers in other parts of the country had done the same thing, they would have an immense body of evidence shewing the advantages of systematic timbering. When he had the honour of giving lectures at the Yorkshire College, he had always taught his pupils that "two sound props were much better than one broken one;" and that this was another way of stating "Have plenty of timber in your working-places, then you are not likely to have so many accidents, nor any increase in your timber-bills, because your timber-bills are incurred by having so much broken timber. If you can set the same prop twice, it is cheaper than if you could only set it once." There were many pits where the same system would not apply, but as he (Mr. Lupton) understood, the idea was that in every pit, in every seam, and perhaps in every district, there should be some carefully thought-out plan of timbering, and this, reduced to writing, should be the rule in that district until those who were responsible thought fit to alter that rule.

Mr. T. W. H. Mitchell said the colliery-manager had to consider the workmen's views, and the probability of increased cost incurred by asking the colliers to timber as they had hitherto been doing, on a system which, being set forth in writing, appeared to them to be something novel. At many collieries, he thought that practically a system of arranging the timber in rows was in force, and although it was not posted in each district, it was posted in the minds of the officials and workmen. There would be difficulty in enforcing hard-and-fast rules, and many of the members knew that the adoption of simple rules had caused enormous trouble, although they only recorded what had been done in the past. Then again they would find, on occasions, after the rules had been posted—he would not say very often—that a nightman, probably under the supervision of a deputy, would build a pack-

wall; but it would not be properly filled, or filled to the top, and when the first bump came, probably the man working next morning in the place was buried under the pack, which had simply been a thin wall instead of being a proper support. Mr. Pickering wished to insist that colliery-managers should always bear the timber question in their mind, and try to educate their officials, and that the officials should in turn educate the collier.

Mr. H. RHODES remarked that the death-rate from falls of roof and side had practically remained stationary during the past 10 years. During that time 9 accidents had occurred at a large colliery from falls of roof, but not one actually at the working-face. This was a singular fact, and if the other accidents mentioned by Mr. Pickering had occurred in the same way, it would appear that systematic timbering could not have prevented any of them.

Mr. R. ROUTLEDGE, with regard to the suggestion of employing specially qualified men to set timber, stated that in longwall workings it was desirable that the men should set their own timber. He wished to point out that mining-engineers were most anxious to do what they could to enhance the safety of their workmen, but at the same time they did not wish to be crushed by further burdens. They were overburdened by legislation in England.

Mr. I. HODGES said that there would be considerable difficulty in revising any method of working for which the miner had a fixed price-list. It would be a gigantic task to alter the conditions under which miners were working at present, and it was impossible to employ other men to draw or set timber, unless the coal-owners were prepared to pay the whole of the cost. Mining-engineers, who were daily dealing with labour problems, were absolutely agreed that it would be impossible to obtain any rebate from the workmen if they were relieved of the timbering of their working-places. Nevertheless, they ought to look at the enhanced safety of the mine, as the cost of ensuring that safety was not an actual loss; and it did not always imply that the cost of working the coal would be increased. He agreed that the timbering should be done from the goaf, and that the roof should be allowed to settle in a systematic manner. The miner received with alarm any suggestion that was made, and he agreed with Mr. Mitchell that they objected to the details of their work being recorded in writing unless it was accompanied by an increased price.

Mine managers desired practical rules, which, possibly after revision, would be acceptable to all concerned.

Mr. M. H. Habershon stated that there were collieries in this district, working coal by machinery, where the method of timbering was very similar to that shewn in the sketches attached to Mr. Pickering's paper. The system was enforced without any special rules or notice posted in the pit.

Mr. J. R. R. Wilson (H.M. Inspector of Mines) remarked that it would have been very interesting if the members would read the reports of H.M. inspectors of mines respecting the 9 accidents referred to by Mr. Rhodes. In the Yorkshire mines-inspection district, there were only two or three collieries at which plans of the system of timbering were placed in the box-hole. In Lancashire, he had seen plans on a large scale and on wooden boards, giving the workmen explicit instructions as to setting timber. The timbering rules should be varied from time to time; and further, the deputy or undermanager was allowed a certain amount of latitude, and could order alterations if they were necessary.

Mr. John Gill said that if notices were posted up the workmen would not read them, and the special timbering rules would be similarly neglected.

Mr. W. H. Pickering (H.M. Inspector of Mines), replying to the discussion, agreed that every manager must adopt a system suitable for his own particular pit. The paper was read with the object of eliciting the views of Yorkshire managers on the subject of systematic timbering. He thought that nowadays there was plenty of timber placed in the stalls, but difficulty was experienced in getting it set, and he desired that it should be systematically set. He could not agree with the statements that the workmen did not read the rules, and that they would not take an interest in the subject. He thought that perhaps he had not expressed himself clearly as to the employment of skilled men to set timber, as he did not mean specially appointed men, but that men who were skilled colliers should be allowed to set timber. He was aware that in some mining districts special men were appointed to set timber; much might be said in favour of such a system, but it was not practicable in all mines. In his opinion, lids formed a very important part of any system of timbering, and should be

systematically used. H.M. inspectors of mines often visited collieries, working almost identical seams: in one, the system of timbering was admirable, and in the other there would be no system. H.M. inspectors of mines wanted the worst raised to the standard of the best-managed collieries. He was not going to defend the Courrières system, but he thought that the report had been misunderstood.

Mr. JOHN GERRARD (H.M. Inspector of Mines) said that he visited the Courrières collieries, to see the system of timbering, the conditions under which the system was applied, and to ascertain the practicability of applying the system in this country. The report* (which was issued as a supplement to Dr. Foster's report†) was an incidental report, and it was not intended to convey the idea that the Courrières system could be applied to all mines in this country.

The discussion was then adjourned.

DISCUSSION OF MR. W. SCOTT'S PAPER ON "THE CRAIG COAL-WASHER."‡

Mr. C. R. Claghorn (Wehrum, Indiana County, Pennsylvania, U.S.A.) wrote that there was a great similarity between the Craig washer and the Campbell washer; and many points made by Mr. Scott in his description of the operation of the Craig washer applied equally well to the Campbell table.

In view of his (Mr. Claghorn's) paper on the Campbell table, he could only say that he had thought up to the present moment that he was the first to apply the filtration-system of washed-coal storage in pits or bins; but he found, after reading Mr. Scott's paper, that he had been working along the same lines. In the light of his experience, he would ask a few questions in the way of discussion. Taking the circular bins as illustrated on Plate XI.§ he asked what arrangement Mr. Scott made for the reloading of the drained washed coal. His first experiment made three

* *Report of Four Inspectors of Mines, etc.*, 1901.

† *Trans. Inst. M.E.*, 1900, vol. xx., page 164.

‡ *Ibid.*, 1902, vol. xxiii., page 179.

§ *Ibid.*, 1902, vol. xxiii., page 182.

years ago, in this connection, was with an overhead structure (with the coke-oven charging larry tracks beneath) of rectangular section. Into this box, the coal was sluiced with the wash-water, the water filtering off through the coal-mass by means of suitable conduits made in the bottom and sides. He found that the coal was packed so hard and fast that it could not be got down through any kind of gate or door in the bottom, and he had to arrange the bin so as to have a bottom which was completely removable in small sections, plank by plank, in order that the stored coal could be removed. He had subsequently modified his plans, so that the storage and filtration is in pits in the ground, the reloading being done by clam-shell buckets operated from gantries. This system works very well, and has overcome the difficulty referred to.

He would like to ask what percentage of moisture Mr. Scott found in the drained coal, and how far this could be reduced by longer drainage. In his experience, the moisture was reduced to about 6 per cent in 72 hours. After that time, it remained practically the same, apparently being held by capillarity, and even stirring up or handling did not reduce this moisture to any appreciable amount, except so far as exposure to the air might dry the coal.

The beauty of this system, apart from points of economy, was in the perfect recovery of the sludge. This was disseminated (as it should be) entirely throughout the washed coal-mass, and formed a uniform product for coking. By any other system, this sludge was recovered by itself; the oven or ovens which received it must be treated somewhat differently, and the resulting coke-product would be of a quality unlike the usual product.

Furthermore, a plant washing small coal, suitable for mechanical stoker-use for steam-raising, had the advantage of receiving the sludge along with the rest of the marketable product; but, if recovered separately, it would have to be remixed by a separate operation or thrown away, as by itself it is of no value for steam-raising, being too finely divided to permit of its being fired by hand or machinery.

Mr. William Scott (Leeds) wrote that he first turned his attention to the necessity of recovering the finer portions of coal, which hitherto had been lost in the settlings, in 1895. Then a

brick hopper, 20 feet high and 15 feet square, was erected, having a bottom lined with maltkiln-tiles, which answered admirably so far as drainage was concerned. Three hoppers accommodated the quantity of coal treated, one hopper being charged, one draining, and from the other coal was drawn. He had experienced the trouble complained of by Mr. Claghorn, but the greater part of the coal could be withdrawn by pottering with a long iron rod through the sliding-door at the bottom of the hopper. The Craig system seemed to him to be immeasurably superior to the hopper-system, as the tank, being circular in form, the process of unloading the hopper is done mechanically by a series of revolving knives taking out a core, about 2 feet in diameter, after which a revolving circular vertical scraper is gradually worked downward and at the same time sweeps the remainder of the contents of the hopper into this central space, whence eventually it falls through the door at the bottom into the coke-oven tub. He agreed with Mr. Claghorn's remarks as to the period of drainage, and he had found that after a certain time no further reductions of moisture occurred. He did not think that it would be desirable to reduce the amount of moisture remaining in the washed coal below 6 per cent.; otherwise owing to the lightness of the product, there would be a loss in exposed positions such as the top of a coke-oven, where it might be scattered from the top of the tub; and there would be greater waste in charging the oven from the tub, where there is often a drop of 4 or 5 feet due to varying gradients of the tram-road.

THE MINING INSTITUTE OF SCOTLAND.

ANNUAL EXCURSION,
HELD AT DOUGLAS COLLIERY, AUGUST 16TH, 1902.

The members were received by Mr. Robert Russell, managing director of the Coltness Iron Company, Limited, Mr. Douglas Jackson, his assistant, and the officials of Douglas colliery, and shewn over the works.

DOUGLAS COLLIERY.

BY DOUGLAS JACKSON.

Douglas colliery is situated in the parish of Douglas and county of Lanark, and about 8 miles from the town of Lanark, on the Muirkirk branch of the Caledonian railway.

Two pits are sunk, 75 feet apart, and there is a day-level mine at Howgill, which cross-cuts the highly-inclined strata to the same coal-seams to which the pits are sunk. The Lord Dunglass pit, 16 feet by 10 feet within the barring, is used for winding and pumping. The Lady Mary pit, 13 feet by 10 feet, is also used for winding and is the upcast shaft for the ventilation of the colliery. The pits are sunk to a depth of 786 feet, and pass through the following seams of the Lower Coal-measures:—*

Names of Seams.	Thickness of Seams. Ft.	In.	Depth from Surface. Ft.	In.
Newtonfoot Gas Coal-seam ...	1	7	90	0
Ellenora Coal-seam	4	2	313	6
Index Limestone	—		455	3
Nameless Coal-seam	2	0	509	0
Wee Drum Coal-seam	4	5	561	0
Big Drum Coal-seam	6	8	569	4
Skaterigg Coal-seam	3	3	609	0
Kirkroad Coal-seam	4	8	654	8
Stoney Coal-seam	3	3	672	6
Back Coal-seam	5	0	759	8
Robb Coal-seam	2	2	786	0

* See also "The Douglas Coal-field, Lanarkshire," by Mr. Robert Weir, *Trans. Inst. M.E.*, 1899, vol. xvi., page 436.

The combined thickness of the coal-seams, at the pits, is 37 feet 2 inches, but most of them increase gradually in thickness towards the outcrop, where their combined thickness is 55 feet.

The seams are being worked forward to the boundary by the stoop-and-room method. The rooms are driven 10 feet wide, the stoops are 200 feet square, and the latter will be worked by the longwall method, backwards from the boundary. The workings to the rise have a gradient of 1 in 4, and the loaded hutches are run down by self-acting inclines to the levels, and are drawn by ponies to the pit-bottom.

Howgill Day-mine.—A small area of the coal-field, severed from the pits by the "great dyke," a large downthrow fault to the south-east of about 300 feet, is worked by the Howgill day-mine on the stoop-and-room method, the stoops being formed 35 feet long on the level course, by 20 feet to the rise, and the rooms are driven 10 feet wide. The seams are inclined at an angle varying from 40 to 60 degrees from the horizontal. The loaded hutches are lowered to the levels on carriages worked by the back-balance system, and afterwards drawn by ponies in rakes of 20 at a time along the day-level mine a distance of 2,100 feet, the declination outwards being 1 in 144. The hutches are then hauled to the Lord Dunglass and Lady Mary pits, a distance of about 4,600 feet on a tramway having gradients varying from level to 1 in 6, by means of an endless haulage-rope, worked on the bogie system, three hutches being attached to each bogie. The signalling for the haulage is done by a combined telephone arrangement, and can be operated from both ends. The ventilation of the Howgill workings is produced by a high-speed forcing-fan, 4 feet in diameter, driven by an electromotor running at 700 revolutions per minute, giving a total quantity of 12,000 cubic feet of air per minute.

Winding-engines, etc.—The winding-engines, at both pits, are of the same dimensions, each consisting of two horizontal cylinders of the trunk type, 20 inches in diameter by 4½ feet stroke, with drums, 12 feet in diameter by 3 feet wide. Both winding-engines are fitted with Frew equilibrated slide-valves, suitable for a steam-pressure of 120 pounds per square inch, and with Bertram visors for the prevention of over-winding.

The pithead-frames are of pitchpine, and the pulleys are 12 feet in diameter. The cages, made of steel, are single-decked for two steel hutches placed end to end, and carry about 11 cwts. of coal each.

Ventilation.—The ventilation of 80,000 cubic feet of air per minute, at ¾ inch of water-gauge, is produced by a Waddle fan, 25 feet in diameter, running at 54 revolutions per minute. It is driven by a horizontal engine with a single cylinder, 20 inches in diameter by 30 inches stroke, and has a large margin of power for increasing the ventilation when necessary. No fire-damp has been known to exist in the locality, and open lights are used in all the workings.

Pumping Plant.—The compound horizontal differential Hathorn-Davey pumping-engine, placed at the surface, was erected in 1897. The cylinders are respectively 38 inches and 66 inches in diameter, by 10 feet stroke. The exhaust-steam from the engine is conveyed down the shaft to an ejector-condenser, at a depth of 90 feet, where the pump discharges its water into a day-level driven from the Douglas water, and a vacuum is produced of 13 pounds per square inch. The pumps are actuated by a pair of 15 feet bell-cranks, built of steel, attached direct to the engine; and each works a pair of single-acting ram-pumps in two lifts. The top-lift pumps, 20 inches in diameter by 10 feet stroke, are placed in the shaft at a depth of 384 feet from the surface. The rising-main is 19 inches in diameter. The pump-rods are made of pitchpine, 16 inches square, in 40 feet lengths, strapped together by four wrought-iron plates, each 22 feet long, 12 inches wide and 1 inch thick. The lower-lift pumps, 12 inches in diameter by 10 feet stroke, are placed at the pit-bottom, and discharge their water through a column of pipes, 11 inches in diameter, into the 384 feet level. The pump-rods, made of pitchpine, 12 inches square, and strapped together by four wrought-iron plates, are connected to the 16 inches pump-rods by forged-iron crossheads: the rods being thus made to balance each other. The pumping-engine generally works about 16 hours per day, at an average rate of speed of 4½ strokes per minute, and discharges about 1,200 gallons of water per minute; but it is capable of working at 6 strokes, and would

then discharge about 1,600 gallons of water per minute. Four catch-beams are placed in the shaft, as a provision against breakage of the rods or making too long strokes. A steam crab-winch, with a pair of cylinders, 8 inches in diameter by 12 inches stroke, geared to lift a weight of 35 tons, is built in readiness for any repair to the pumps or pump-rods that may be necessary, but it has not as yet been required.

Boilers.—Steam is generated in 6 Lancashire steel boilers, 30 feet long by 8 feet in diameter, constructed for a working pressure of 120 pounds per square inch, but working at present 80 pounds. The boilers are fitted with mechanical stokers (4 Vicars and 1 Bennis) and the sixth boiler is being fitted with the Munro perfect-combustion appliance. The draught for the boiler-fires is produced by a Chandler single-inlet exhausting fan, 8½ feet in diameter, running at 250 revolutions per minute, driven direct by an engine, with a cylinder 15 inches in diameter, and discharging the gases into a chimney, 30 feet high. A Green economizer, consisting of 360 tubes, is placed in the main flue, between the boilers and the fan. The feed-water is forced through the economizer into the boilers by a Pearn pump, with two cylinders, 8½ inches in diameter by 8 inches stroke; and the temperature of the water is raised to 260° Fahr. before entering the boilers. The temperature of the flue-gases, on leaving the boilers, is about 600° Fahr., and, after passing the economizer, it is reduced to about 280° Fahr.

Pithead.—The pithead-scaffolding and screen-erections are built of wrought-iron girders, resting on cast-iron columns. The floor of the pithead is laid with cast-iron plates, and the whole building is enclosed with galvanized corrugated iron. For each of the three screens, there is a revolving tippler, worked by friction-gear from the screen-engine, with a backward movement to moderate the fall of the coal. In each screen, the coal-feeding or spreading plate, the screen proper, and the picking-table, are combined in one piece, the longest being 93 feet, and made of steel. The feeding-plate is 21 feet long by 5½ feet wide, with a fall of 1½ inches per foot; the screen, with perforations, is 15 feet long by 5½ feet wide, with a fall of 3½ inches per foot; the picking-table is 57 feet long by 4 feet wide, with a fall of 1½ inches per

foot; and the combination rests and vibrates on rockers. Each screen is actuated by a steam-engine, with a cylinder 8 inches in diameter by 12 inches stroke.

The Luhrig coal-washing plant is capable of treating 500 tons of dross per day.

The railway-sidings have a gradient of 1 in 80, on one of which there has just been fitted a wagon-controller, which permits of the coal-wagons, when they are loading at the screens, being moved and stopped as the trimmer requires, without the necessity of his descending to the railway to take out or put in the trig, the controller being operated by the trimmer at the wagon-top.*

A steam-hoist is used for raising material from the surface to the pithead-level, with a cylinder 12 inches in diameter by 8 feet stroke.

Electric Machinery.—The electric installation is driven by a Tangye girder steam-engine, with Tangye-Johnson automatic cut-off gear, with a cylinder, 14½ inches in diameter by 28 inches stroke. A belt from the flywheel of the engine drives counter-shafting, from which three dynamos are driven by belting. One dynamo, with an output of 75 ampères at 400 volts, and 700 revolutions per minute, supplies current to the electromotor which drives the ventilating-fan at the Howgill day-mine, at a distance oi 4,600 feet. It also supplies current to a motor which drives a three-throw pump, with rams, 6 inches in diameter by 9 inches stroke, placed at the side of the Douglas water; and when running at a speed of 50 revolutions per minute it discharges 120 gallons of water per minute to a reservoir, which supplies the boilers, etc. Another dynamo, with an output of 80 ampères at 250 volts, and 750 revolutions per minute, is used for lighting the works at the surface, and the pit-bottoms and underground stables. The third dynamo, of the same dimensions as the last, is used for lighting the workmen's houses at the village of Douglas Water, about 1 mile distant.

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* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 122.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD AT DOUGLAS COLLIERY, AUGUST 16TH, 1902.

MR. HENRY AITKEN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. JOHN BROWN, Kilmarnock.
Mr. ADAM CHALMERS, Cultrigg Colliery, Fauldhouse.
Mr. JAMES DUNN, Kenmuir Colliery, Mount Vernon.
Mr. WILLIAM HILL, Hattonrigg Colliery, Cleland.
Mr. JOHN F. HOWAT, Stobbs House, Kilwinning.
Mr. WILLIAM McCREATH, 208, St. Vincent Street, Glasgow.
Mr. JOHN RODGER, Hurlford.
Mr. WILLIAM WILSON, Climpy Colliery, Forth, Lanark.
Mr. ROBERT YOUNG, Bellfield Colliery, Coalburn.

ASSOCIATE MEMBER—

Mr. THOMAS B. DUNN, 21, Bothwell Street, Glasgow.

ASSOCIATE—

Mr. ROBERT CRAWFORD, Muirfield, Loanhead.

STUDENT—

Mr. ROBERT LAWRENCE ANGUS, Lugar Iron-works, Cumnock.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN DOWELL'S ROOMS, EDINBURGH, OCTOBER 11TH, 1902.

MR. DAVID M. MOWAT, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. ANDREW BARRIE, Southrigg Colliery, Armadale.
Mr. JAMES CARRUTHERS, Lovell Flat, Otago, New Zealand.
Mr. ROBERT FLEMING, East Roughrigg Colliery, Avonbridge.
Mr. H. C. FORRESTER, Tullibody House, Cambus.
Mr. ANDREW HENDERSON, Gartsherrie Colliery, Coatbridge.
Mr. GEORGE MILLER, Jherria Post Office, District Manbhum, Bengal, India.
Mr. ALEXANDER RANKINE, Polbeth, West Calder.
Mr. FRANK B. SMITH, Calgary, North-West Territory, Canada.
Mr. GEORGE FREDERICK TURNER, Clyde, Otago, New Zealand.
Mr. JAMES WATSON, 91, Mayfield Road, Edinburgh.

ASSOCIATE MEMBER

Mr. ROBERT FORRESTER, 142, West Nile Street, Glasgow.

DISCUSSION OF MR. JAMES BARROWMAN'S PAPER ON "WHAT IS THE LEAST POSSIBLE WASTE IN WORKING COAL."*

The CHAIRMAN (Mr. D. M. Mowat) remarked that Mr. Barrowman had introduced a most important subject, in view of the fact that the Royal Commission on Coal-supplies were including it in their investigations.

Mr. JAMES BARROWMAN said that the difficulty of getting wayleaves, referred to by Mr. R. T. Moore,† was considered ten

* *Trans. Inst. M.E.*, 1902, vol. xxiii., pages 55 and 149.
† *Ibid.*, page 152.

years ago by the Royal Commission on Mining Royalties, who obtained evidence upon it. The result of that enquiry was generally to the effect, that while in a few cases there might be difficulty in coal-masters obtaining wayleaves, when they desired them: on the whole it was not a public question, and was more a matter between proprietors than one affecting the coal-masters and the public. The circumstance that any mineral-proprietor should hold his minerals and prevent them from being worked until they were cut off, or drowned, or otherwise rendered unworkable, must be a very rare occurrence, and the refusal of a proprietor to give a wayleave through his lands for coal can, so soon as it becomes a question affecting the public prejudicially, be overcome by Act of Parliament. The Royal Commission on Mining Royalties suggested a simpler tribunal before which unreasonable landlords could be brought, and expressed the opinion that "if such a remedy were open to persons who conceived themselves to be aggrieved by the unreasonable refusal of facilities for the passage of minerals, difficulties would be readily arranged by private agreement, and that only in very rare instances, if ever, would it be necessary to have recourse to compulsory proceedings."

On the motion of the Chairman, a hearty vote of thanks was given to Mr. James Barrowman for his valuable paper, and the discussion was closed.

DISCUSSION OF MR. JAMES BAIRD'S "DESCRIPTION OF UNDERGROUND HAULAGE AT MOSSBLOWN COLLIERY, AYRSHIRE."*

The CHAIRMAN (Mr. D. M. Mowat) said that the detail of haulage arrangements was one of the most important subjects that could be discussed, because success or failure depended on the efficient combination of the details of the haulage. They might have a grand scheme, and yet everything might go wrongly simply because the details had not been properly studied. He asked whether Mr. Baird had experienced any difficulty in placing a new rope on the horizontal wheels, for he had been told that difficulty had been experienced in adjusting the rope on a Clifton

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 155.

wheel, as the rope invariably became slack and fell down, while it was being put on.

Mr. JAMES BAIRD said that he had no difficulty in putting a rope on to horizontal wheels, because the adjustment of the rope on to the Clifton pulley was the final operation: he took the rope round the full length of the haulage-road, and wound the last coils of the rope around the Clifton wheel. However, as he had not yet renewed the rope, he could not give his actual experience in that particular.

Since reading the paper, he had had indicator-diagrams taken of the work done by the engine; and the proposed haulage in No. 2 pit, as described under the heading of " Future Developments,"* had been put into operation. The length of this new haulage roadway was 1,800 feet, but as it was found necessary to alter the gearing of the engine, as formerly proposed, a Clifton wheel (7 feet in diameter) was fitted loose on the engine-shaft, and manipulated by a friction-clutch and screw. A perusal of the diagrams taken from the hauling-engine gives the following results:—With the three haulage-roads working in No. 1 pit, and with steam cut off at half-stroke, the indicated horsepower was 33·36. In overcoming friction and driving only the No. 1 pit band-rope, and with steam cut off at half-stroke, the indicated horsepower was 5·74; and under the same conditions, with steam cut off at quarter-stroke, the indicated horsepower was 4·93. Again, with the three haulage-roads in No. 1 pit and the No. 2 pit haulage-road, all working simultaneously under load and with steam cut off at half-stroke, the indicated horsepower was 46·55; while under the same conditions, but with steam cut off at quarter-stroke, the indicated horsepower was 36·04.

The further discussion was adjourned.

DISCUSSION OF MESSRS. JOHN HOGG'S, THOMAS MOODIE'S AND THOMAS ARNOTT'S PAPERS ON "THE WORKING OF CONTIGUOUS, OR NEARLY CONTIGUOUS, SEAMS OF COAL."†

Mr. ROBT. McLAREN (Edinburgh) asked whether other members, who had worked these seams, had had the same experi-

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 161.

† *Ibid.*, 1902, vol. xxiii., pages 280, 282 and 288 respectively.

ence,* that in working the Main seam, within 12 feet or so of the Pyotshaw seam, the latter was "not found to be affected." He was a little sceptical on the matter, because in his experience he had found that it mattered not which seam was worked first, as the remaining seam was affected by the intervening strata being disturbed.

The CHAIRMAN (Mr. D. M. Mowat) said that, in his experience, when working the Pyotshaw and Main seams, 12 feet apart, the working of the Main coal first, made the Pyotshaw coal very tough and more expensive to work; and the additional cost to the miner would exceed 1d. or 2d. per ton. In his opinion, where 10 or 12 feet of strata intervened between the seams, the better way was to work the Pyotshaw seam first, and then follow in the Main seam. The Main seam would then be a little harder to work, but larger coal would be produced.

Mr. THOMAS ARNOTT (Newton) stated that, in working the Ell and Main coal-seams at Hallside colliery, where they are about 66 feet apart, it had been the practice to work the Main seam first, as it was a little easier to work; and on giving precedence to the Ell seam, it was found that the cost of working the Main seam was increased by about 2d. per ton. Larger coal was got by the latter than by the former method, but the improvement was not so great as to warrant an increase of 2d. in the cost of working.

Mr. R. KIRKBY remarked that Mr. Moodie said in his paper that "sometimes the upper leaf [splint coal] is worked back."† He did not think that this had ever been done, and at any rate it was not done now. The panel system, too, was not, and had never been, in operation at Leven colliery. It was quite possible that this system had been proposed, and drawn out, but it had never been adopted in practice.

Mr. ROBERT MARTIN (Portobello) remarked that his experience at the Niddrie collieries had been very similar to that described by Mr. Arnott.

Mr. J. M. CAIRNCROSS (Coatbridge) said that, at Rosehall colliery, the Main and Pyotshaw seams had been worked for the last 35 or 40 years, and various methods of working had been

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 280. † *Ibid.*, page 284.

tried. The system which had been found to yield the most satisfactory result was to work the Main seam first, by longwall inwards, with short, well-built walls. After a period of not less than 3 years, sufficient to allow the weight to come on again, the Pyotshaw seam was worked also by longwall inwards. The distance between the two seams varied from 12 to 18 feet.

The further discussion was adjourned.

DISCUSSION OF MR. RICHARD KIRKBY'S PAPER ON "THE DYSART, WEMYSS AND LEVEN COAL-FIELD, FIFESHIRE."*

Mr. R. KIRKBY, referring to Mr. H. Aitken's remarks, said that the principal shell found in the marine bed is *Lingula*, and this mollusc is known by geologists as a marine shell. It had been noticed in the coal-fields of Lanarkshire, Durham and Staffordshire by different observers, and special attention had been drawn to it as shewing that marine conditions prevailed at times in the Coal-measures. It seemed quite certain that there had been alternations of what had been called marine and lagoon conditions during the deposition of both the Coal-measures and of the Carboniferous Limestone series. Sir Archibald Geikie had drawn special attention to a very interesting case at Cults lime-works, near Pitlessie.† Close above the Hurlet Limestone, there is the following section:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.
1	Thick group of dark shales	-	
2	COAL	1	3
3	Fire-clay	1	6
4	Limestone, composed of crinoids and numerous other marine organisms	2	6
5	COAL	0	10
6	Fire-clay with rootlets	2	0
7	Sandstone, with streaks of carbonized plants ...	0	10
8	Fire-clay	0	6
9	Blue shales and fire-clays ... ... 8 feet to	10	0
10	Calcareous shale	1	6
11	Blue shale	1	3
12	Calcareous shale	1	0
13	Hurlet Limestone	-	

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 291.

† *Memoirs of the Geological Survey, Scotland: Geology of Central and Western Fife and Kinross-shire*, page 87.

The changes from one condition to another appear to have taken place very suddenly, as shewn in this section.

He was indebted to Mr. R. T. Moore for his remarks on the correlation of the seams in different districts, and regretted that he had not sufficient knowledge of the different coal-fields to enable him to follow up this question. Considerable difficulty was experienced in tracing a coal-seam through different districts, as even in a stretch of only 2 or 3 miles in one coal-field, a seam varied so much as to be hardly recognizable at different points.

According to Mr. James S. Grant Wilson,* the depth from the Seven-feet to the Duddy Davie or Cairncubbie seam of Fifeshire is about 2,300 feet.

He might mention that a diamond bore-hole was being put down to the Limestone coal-seams, from a point somewhere near the top of the Millstone Grit series. This section would prove very interesting to geologists, and one would hope, also to mining-engineers.

Mr. Robt. McLaren (Edinburgh) asked Mr. Kirkby whether the fires that had occurred at Balgonie Colliery,† referred to the Julian pit or to the Lochty pit of that colliery.

Mr. R. Kirkby said he believed that the fires of which he had spoken had taken place at the Lochty pit.

Mr. McLaren said it should be noted, in connection with the working of the seams at Balgonie colliery, that while the management endeavoured to get all the available coal, they at the same time sought to work the coal in such a way as to prevent the occurrence of fires from spontaneous combustion. Unless some system could be adopted which would lessen the risk of fire by spontaneous combustion, he thought it was very likely that many tons of the Dysart Main coal-seam would be lost. It was quite true that of recent years they had managed to keep clear of fires at Balgonie colliery, but in previous years these outbreaks were very numerous in that district.

Mr. H. M. Cadell (Bo'ness), referring to the occurrence of *Lingula*, said that it was very important to notice the fossils in connection with any particular seam of coal, in order to follow it from

* *Geological Survey of Scotland: Vertical Sections*, sheet 2, 1889.

† *Trans. Inst. M.E.*, 1902, vol. xxiii., page 297.

one place to another. *Lingula* was found in the roof of the Smithy coal-seam of Bo'ness. It was a fossil belonging to the marine series, and appeared to have lived in salt-water. There had never been any connexion traced or, at all events, the seams had never been identified, between Bo'ness and Fife. He hoped at some time to furnish the members with a paper on the relation between the Linlithgowshire coal-seams and those in Fifeshire. In his paper on "The Carboniferous Limestone Coal-fields of West Lothian,"* he had shewn that there was originally no connexion between two different sets of seams at Bo'ness and Bathgate, and that they had apparently been formed in unconnected areas during the Carboniferous Period.

Mr. JOHN CADMAN (Edinburgh) said that he had read Mr. Kirkby's paper with considerable interest. He noted that in the Dysart Main seam, at the Frances pit, there was a thickness of 23 feet 10 inches, which thinned out to 7 feet at the Cameron pit, showing a reduction of 70 per cent., over a distance of 5 miles, or an attenuation to the north-east of 14 per cent. per mile. In the Chemiss seam, a thickness of 10 feet 9 inches was reduced to 4 feet 10 inches over a distance of 4 miles, indicating also an attenuation of about 14 per cent. per mile. He (Mr. Cadman) thought this very interesting, and he asked whether Mr. Kirkby could give any further information as to the actual attenuation of the total thickness of the Coal-measures along this line to the north-east. In the North Staffordshire coal-field, the Coal-measures thinned from east to west at the rate of about 12 per cent. per mile, but the seams of coal were not altered to any extent. An attenuation of this kind pointed to two suppositions, either that the coal-field was approaching its margin or extremity, or that it was approaching a fold. Mr. Kirkby referred to 1,440 feet of Lower Coal-measures lying below the Red Sandstone beds. Could Mr. Kirkby state the datum-line from which this measurement was taken, and whether there was a definite index-bed, or whether the division of the Upper Red beds from the Coal-measure beds below was simply a matter of colour?

Could Mr. Kirkby say what were the species of *Carbonicola* forming the so-called "mussel-band" lying above the Barncraig seam? Recently, he (Mr. Cadman) had observed a similar

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 372.

so-called "mussel-band," composed of *Carbonicola robusta*, extremely distorted and crushed, lying a few feet above the Splint coal-seam, at a north Lanarkshire colliery, near Longrigg. If the species found in the band above the Barncraig seam in Fife were the same as those found in the band occurring above the Splint seam at Longrigg, then it would be reasonable to state that the Barncraig seam of Fife was the Splint seam of Longrigg. Fossil bands, such as this, are of great importance in correlating seams in different localities of a coal-field.

Mr. R. KIRKBY said that he did not know the species of *Anthracosia* or *Carbonicola* occurring above the Barncraig seam, but would ascertain it, if possible. With regard to the thinning-out of the strata between the seams, as well as the thinning of the seams themselves, he might point out that the vertical sections* showed that the thickness of the strata between the Eight-feet and Chemiss seams at Durie, was only about one half of the thickness at Wemyss.

Mr. ROBERT MARTIN (Portobello) stated that the Dysart and Wemyss coal-seams were the same as those on the Musselburgh side of the Firth of Forth, known as the Newcraighall or the Cowpits seams, as they had been worked at both of these places.

The further discussion was adjourned.

The following paper by Mr. JOHN D. MILLER on an "Apparatus for Controlling Railway-wagons while loading at Colliery-screens" was then read:—

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 308, Plate XIX., Fig. 3.

APPARATUS FOR CONTROLLING RAILWAY-WAGONS WHILE LOADING AT COLLIERY-SCREENS.

By J. D. MILLER.

The Miller-Yates apparatus described in this paper is used for controlling the movement of wagons upon railway-inclines, and especially at colliery screens; and by which wagons in motion may be slowed and stopped at points convenient for loading or unloading, or for being trimmed in loading operations, without the use of a wooden trigg or the constant attendance of a wagon-shifter.

By the use of this apparatus, it is claimed that at many of the pits throughout the country, the services of a special man to shift the wagons, while in course of loading, can be dispensed with, and a very substantial saving in wages thereby effected, while perhaps, at the same time by its use, many accidents may be prevented. The apparatus is controlled, and the shifting of the wagons done by the wagon-trimmer from the level of the scaffold on which he stands, without requiring him to come down to the rail-level. It is operated by a hand-lever, or by hydraulic or other power-appliances, from any point within convenient reach of the trimmer in charge of the loading-operations. It operates upon the axle of the wagon, and does not interfere with the rails or railway. It is very simple, easily fixed and put to work, the whole apparatus being placed in the centre of the railway under the screen or table, and fixed to the railway-sleepers.

Fig. 1 is a longitudinal elevation and Fig. 2 a plan of the apparatus. The apparatus is composed of a wooden lever-bar, A, strapped with iron-plates, placed longitudinally between the rails and above their level, and pivoted to a cross-bar, B, carried on brackets fixed to two long wooden beams, C, secured to the sleepers at a point where an incline is formed so as to facilitate the movement of the wagons. To the upper or free end of the brake-lever, A, and serving as a longitudinal continuation of it, is hinged

or pivoted an iron lever-bar, D, having projecting upwardly from it, a number of equidistant pawls or catches, E. A powerful spring, F, is attached to the pivoted end, B, of the brake-lever, A, to cushion the shock given to the lever by the axle of the moving wagon on coming into contact with the catches. The catch-bar lever, D, which is guided by slotted links, G and H, pivoted to it, and to the two longitudinal beams, C, is raised or lowered vertically by means of a quadrant I, and link, K, by a hand-lever, L, or like means within reach and under the control of the trimmer.

In working the apparatus, the wagons are allowed to run slowly down the incline (which at most collieries is about 1 in 75), until the front axle of the wagon reaches the previously raised lever-bar, A, which slows and stops the wagons. The trimmer, then, by means of the hand-lever, L, lowers the brake-lever, A, and frees the axle of the wagons; and so soon as the

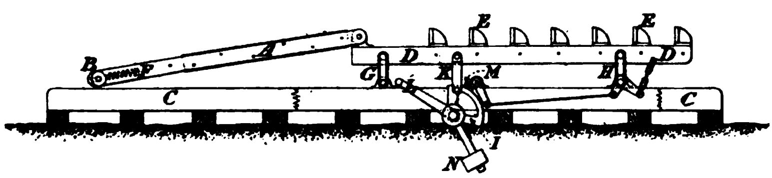


FIG. 1.—SIDE-ELEVATION OF THE MILLER-YATES WAGON-CONTROLLER. SCALE, 6 FEET TO 1 INCH.

axle of the wagon slips over, and passes clear of, the brake-lever, it is caught and held by the pawls or catches, E, on the front lever, D. The loading of the wagon is then commenced, and as it proceeds, the catch-bar, D, is lowered at suitable intervals by the trimmer, allowing the wagon to move forward, step by step, the distance between the catches, in order that, in loading from a screen or shoot, the wagon may be properly trimmed. By the regular and systematic shifting of the wagon, breakage of the coal is considerably reduced.

The brake-lever, A, acting upon the rear axle of the wagon, prevents any sudden movement, and ensures that the wagon shall only shift from one catch to the next in succession. The catches may be spaced, so as to ensure the proper trimming of the wagon.

Instead of the brake-lever, A, and catch-lever, D, requiring to be raised to engage with the wagon-axle, they are normally maintained in the raised position by a counterweight, and lowered

by moving a lever, under control of the trimmer, so as to disengage the axle, and permit of the wagon moving forward from catch to catch.

The apparatus is provided with an automatic safety-brake, M, acting upon the quadrant, I, and obtaining its power from the catch-lever, D. This brake-appliance is not required in the ordinary course of handling empty wagons, but it is a safeguard for use in the event of, say, the wagons coming down upon the brake-lever at considerable speed, or any excessive weight being put upon the brake-lever. Under such circumstances, the axle of the first wagon would engage with and travel upwards along the brake-lever, A, until the front wheels of the wagon got lifted off the rails. That being so, the brake-lever, A, would have an

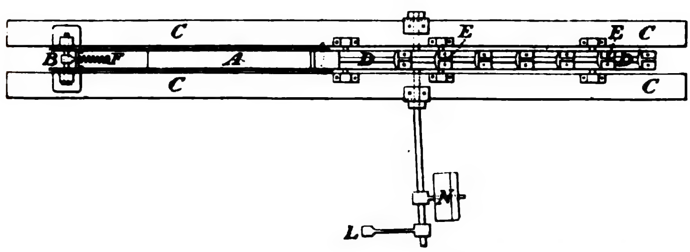


Fig. 2.—Plan of the Miller-Yates Wagon-controller.
Scale, 6 Feet to 1 Inch.

excessive weight thrown upon it, and when the trimmer moved his hand-lever to disengage the axle, the apparatus might be lowered suddenly with a shock. The brake, M, prevents this, and the greater the weight that is applied to the brake-lever, A, the higher the catch-lever, D, is inclined to rise, and consequently, the more powerful does the brake become.

The above-described apparatus has now been working at a modern colliery, under daily supervision, for the last 8 months, and has given satisfaction in every respect. Since the day when it was started, the man who was formerly employed as wagon-shifter has been dispensed with, and the wages saved during that time have more than paid for the apparatus.

Mr. Robert Martin (Portobello) did not think that the apparatus would effect much saving in labour, because some person would be required at the top to regulate the movements of

the wagon, so that the trimmer might be able properly to attend to his own duties. In any case, a wagon-shifter would be required to attend to the empty and loaded wagons behind and in front of the screens. At a busy colliery, it was impossible that the trimmer himself could undertake the combined duties of trimming and moving.

Mr. Roberts (Gorebridge) thought that the services of a second man would be required in the controlling, if, say, a load of six wagons were in front of another load.

Mr. Robert McLaren (Edinburgh) said that in frosty weather, with an incline of 1 in 70 or 1 in 80, there would be difficulty with a load of several wagons in working the apparatus.

Mr. James Barrowman said that a strong point in favour of the apparatus, altogether apart from the question of economy, was its safety. It was surely much safer to attend to a lever on the platform at the top of a wagon, than to run among the wagon-wheels with a trig.

Mr. J. M. Cairncross (Coatbridge) pointed out that the breakage of coal was considerably reduced by the systematic shifting of the wagons secured by the proper working of the apparatus.

The further discussion was adjourned.

Mr. Robert Martin's paper on "Sinking on the Seashore at Musselburgh" was read as follows:—

SINKING ON THE SEASHORE AT MUSSELBURGH.

By ROBERT MARTIN.

Introduction.—Olive Bank colliery is situated in the burgh of Musselburgh on the banks of the Firth of Forth, within 900 feet of high-water mark and about 12 or 14 feet above the level of high tide. Fig. 1 (Plate IV.) shews a cross-section of the Mid-Lothian coal-field, indicating the position of the "edge" seams at Niddrie and Newcraighall and across to Wallyford. The Niddrie coal-seams occur in the Carboniferous Limestone series, and the seams at Olive Bank and Newcraighall are in the Upper Coal-measures.* The Olive Bank seams, known in the district as the "flat" seams, have been extensively worked, farther south, at Stoneyhill, Millerhill and Smeaton.

The strata at Olive Bank have been proved by boring to a depth of 912 feet. The Splint coal-seam is 5 feet thick, at 600 feet; lower down the Rough and Beefie seams; and the Jewel coal-seam, 4 feet 8 inches thick, to which the pits are to be sunk, is at a depth of 912 feet. The section near the surface, so far as this paper is concerned, is as follows:—

No.	Description of Strata.	Thickness of Strata. Feet.	Depth from Surface. Feet.
1	Sand	5	5
2	Gravel	5	10
3	Boulder-clay	22	32
4	Silt or mud	75	107
5	Red sandstone	40	147

Sinking the Cylinders.—Two shafts, 70 feet apart, and each 14 feet in internal diameter, have been sunk through the alluvial deposits into the red sandstone. The shaft-lining consists of a steel cylinder, 18 feet in diameter, lined internally with brick-work and concrete, 2 feet thick. Figs. 2, 3, 4, 5 and 6 (Plate IV.) show the cylinder in various aspects. Fig. 2 represents the whole length of the cylinder, namely, 81 feet, consisting of the cutting-edge ring, 5 feet long and ¾ inch thick, and 19 rings, 4 feet long and ½ inch thick. The cylinder was supplied by Messrs. Somervail and Company.

* "The Mid-Lothian Coal-basin," by Mr. Robert Martin, *Trans. Inst. M.E.*, 1893, vol. vi., page 388.

Both pits were sunk of square shape, 18½ feet inside, through the boulder-clay, and lined with white pine, 9 inches by 4 inches. In this shaft, over 30 feet of the cylinder was constructed and partly lined inside with brickwork and concrete, before any attempt was made to lower it. The cutting-edge ring, *a*, is widened to 18 feet 2½ inches in diameter at the foot, or bell-mouthed, so as to give clearance when lowered. The cone-shaped arrangement of plates, *b*, is intended to stiffen the cutting-edge ring. On the top of the cutting-edge ring (Figs. 5 and 6) is a platform, *c*, supported by angle-iron brackets, *d*, upon which the brickwork-and-concrete lining is built. In the first cylinder that was sunk, in order further to stiffen the cutting-edge ring and to assist in carrying the heavy load of brickwork and concrete, the space between the cone, *b*, and the platform, *c*, was filled with pitchpine blocks, bolted to the cylinder, and these were afterwards removed. In the second cylinder, it was found more simple and as efficient to fill this space with brickwork, each course projecting over the lower one until the full thickness was attained. Fig. 5 shows the interior of the cylinder. Above the cutting-edge ring were added the 4 feet rings, each consisting of 8 plates 7 feet long, attached together by T irons, *f*, 6 inches by 3 inches and ½ inch thick. These T irons extended from one ring to another and tied them together. Each ring is strengthened with 3 horizontal angle-irons, *e*, 3 inches by 3 inches and ½ inch thick (Fig. 5). The angle-irons at the ends of the rings form an internal flange, and the flanges of adjoining rings were fastened together by 56 bolts. Counter-sunk bolts and rivets were used on the outside of the cylinder, which presented a perfectly smooth surface, and reduced sliding friction to a minimum.

The internal lining of the ring consisted of 2 rings of 9 inches brickwork, the bedding of one ring breaking joint with the other so as to blind the joint. Behind the brickwork and next the cylinder, the remaining space of 6 inches was filled with cement-concrete, run into the interstices of the angle-irons, T irons, nuts and rivet-heads. The mortar used for building and concreting was ordinary lime (1 part of shell-lime to 3 parts of sand) and as much Portland cement.

When the square shaft was sunk sufficiently far down, the cylinder was built in it to a height of 8 feet above the surface, and adjusted so as to be exactly vertical. About 2 feet of silt was dug out of the bottom, and brickwork was built in the cylinder so as to

force it into the space, if it did not move. This process was repeated until the brickwork reached above the surface, and its weight proved insufficient to press down the cylinder. In both shafts, this stage was attained when the cylinder had reached a depth of about 75 feet.

The rate of sinking ranged from 3 feet to a few inches per day. The estimated weight of the cylinder and brickwork was about 5 tons per foot. In the sinking of the first shaft, about 200 tons of additional weight of pig-iron was required to force down the cylinder for the last length of 32 feet. The pig-iron was laid on scaffolds supported upon buntons built into the walling. When the first shaft reached a depth of 94 feet, the bottom was forced upward by a water-feeder varying from 300 to 400 gallons per minute. At this depth the cylinder sank, amongst the mud, about 2 feet per day, until it rested on the rock. The surface or skin-friction of the cylinder was about 2½ cwts. per square foot of rubbing surface.

The sinking of the first cylinder took from August 21st, 1901, to January 14th, 1902, to reach the rock-head, or less than 5 months; and the second cylinder took from February 20th, 1902, to July 13th, 1902, to reach the rock-head, also about 5 months.

In the second shaft, a weight of 400 tons of pig-iron was required to force down the cylinder. This gives a skin-friction of 3½ cwts. per square foot of rubbing surface, due to the absence of the large feeder of water, which practically undermined the first cylinder. In both pits, a small feeder of water was encountered in the gravel.

The silt was, at times, so soft as to be difficult to stand upon and tough to dig; but when dry, it was easy to dig with a shovel. In the second shaft, it was necessary, latterly in order to induce a movement of the cylinder, to dig outside the cylinder and to facilitate inrushes of mud and water. As a consequence, the cylinder and silt sank together, and a large surface-subsidence, about 20 feet in depth, was formed round the pit-mouth, by the time that the cylinder had reached the rock.

Both cylinders were sunk sufficiently deep into the red sandstone, so as to dam back the mud, and when this depth was attained, the tops of the cylinders were 26 feet below the surface. The upper portion of the shaft was then built up to the surface-level with 18 inches of walling.

Sinking the Shafts.—When these operations were completed, the work became that of ordinary sinking, except that it was necessary, for some depth below the cylinder, to excavate the sandstone in such a way so as not to undermine and induce an inrush of silt into the shaft-bottom. This was done by carefully hewing and dressing the sides of the shaft to a slightly less diameter than the cylinder, to a depth of 6 feet. At this point, the diameter of the shaft was reduced to 14 feet, thus leaving a ledge or foundation-bed for a brick-wall. This walling was carried upward till the tapered cutting-edge was built in. Below the ledge or foundation-bed for the wall, the shafts were widened out and are being sunk to allow of a thickness of fully 9 inches of brickwork, with which the shafts are being lined. As the sides of the shafts are very irregular, owing to blasting, and as the brickwork is extended into these irregularities, the wall is practically self-supporting.

The feeders of water are confined into and carried downward in hassons, rings, etc., in the sides of the shaft behind the brickwork. This makes a dry shaft, and there is no water on the face of the brickwork. Where necessary, the feeders are caught in rings and run into insets with lodgments, and are dealt with by special stationary pumps.

Consequently only the lowest feeders require to be raised by the sinking pumps. In each shaft, three Evans sinking pumps are placed, two with 12 inches, two with 9 inches, and two with 7 inches buckets by 2 feet stroke. These six pumps, capable of raising 2,600 gallons per minute against a head of 300 feet, are suspended on chains, with 6 inches links of $1\frac{5}{8}$ inches iron, tested to 30 tons, attached to beams either on the pit-mouth or in the shaft, and are raised or lowered as required by means of wire-ropes on hand-cranes.

Owing to the limited area of the shaft, the volume of the feeders of water, and the number of steam-pipes, water-pipes and air-pipes in the shaft, it was found impracticable to sink and wall the shafts simultaneously. The method is to sink and wall a length of 9 to 12 feet, that is, all the work is done below the pumps, which almost fill the shaft at the point where they hang. In this way, no cribbing or timbering is required, unless the strata are extremely soft, and the danger of sinking with from 60 to 70 feet of shaft secured by temporary timbering is avoided Where a

rock seat for the walling is not required or cannot be obtained, a few iron pins or crampets are driven in round the circumference, and when covered with boards they are sufficient to carry the walling until a secure foundation is got. As before remarked, if the wall is built into the sides with a good lime-and-cement mixture, it is self-supporting in a few days.

It may be mentioned that the pumps have sometimes been drowned to a height of 40 feet above the steam-cylinders, and that these continued working, or if stopped, were started until the water was lowered.

To discover the best type of bucket was perhaps the principal difficulty experienced with the pumping. The cost for frequent renewals was serious, not to speak of the loss of time in the sinking operations. Dermatine cups, indiarubber rings, cast-iron blocks lapped with Manila rope and gunmetal angular rings were used, the latter being preferred. In every case, the pump-barrel was lined with gunmetal. As the vibrations of long columns of steam-pipes and water-pipes carried by chains on which the pump was hanging and working was bad for the joints, bracket-pipes have been introduced for each column. Between this bracket-pipe and the pump there is an expansion-pipe which allows the pump and the pipes immediately attached to the pumps to move freely up and down, but above the bracket-pipe the column is stationary.

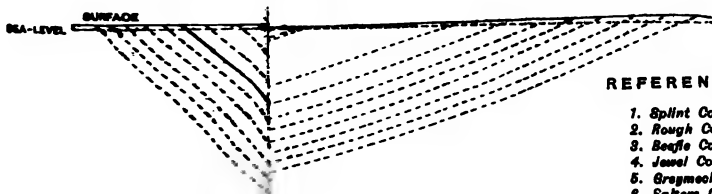
The shafts are fitted with ordinary pitchpine slides attached to buntons for guiding the sinking-kettle. The kettle is kept in position by two pieces of wood bolted across the bow, and at each end of these beams is a recess, which fits the slides. By this device, the kettle can run at a high speed in a shaft filled with pipes, air-tubes, chains, etc. The kettle is discharged on the surface after being disengaged from the slides, which are flexible at the top and is swung out by means of a chain suspended from a beam at the pit-mouth; and the kettle is inverted, being hung at its centre of gravity, into an iron tub placed underneath a scaffold so as to receive the contents.

Mr. Archibald Blyth (Hamilton) asked how far the cylinder varied from the vertical when down.

Mr. Martin replied that it was 18 inches.

"...Seashore at Musselburgh."

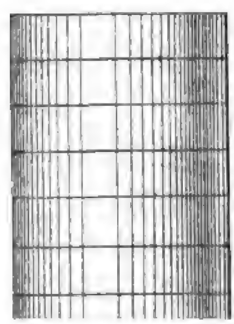
...AL-FIELD.



REFERENCES.

1. Splint Coal
2. Rough Coal
3. Beefie Coal
4. Jewel Coal
5. Greymeeham Coal
6. Salters Coal
7. Nine-feet Coal
8. Fifteen-feet Coal
9. Four-feet Coal
10. Seven-feet Coal
11. Wood Coal
12. South Parrot Coal
13. Great Seam Coal
14. Black Chapel Coal
15. Corbie Craig Coal
16. Real Carleton Coal
17. Carleton Coal
18. North Greens Coal

Scale, 3,600 Feet to 1 Inch.



Mr. H. M. Cadell (Bo'ness) stated that he had been connected with a similar sinking at Bridgeness,* and they had managed to make the cylinders perfectly vertical after having been 20 inches off it. He asked Mr. Martin what was the cost per foot of sinking down to the rock by the process described, and what was the advantage in using steel in preference to cast-iron cylinders. In the sinking at Bridgeness, it was found that when they applied about 400 tons of weights at a depth of about 80 feet below high-water mark, the cylinders would descend no farther. The shaft had been sunk full of water, and when the cylinders stopped sinking the water had to be removed. The material had been excavated by means of a Milroy digger, working in the water like a Priestman grab. The total cost of that sinking of about 100 feet from the surface was £2,200, and it showed that, after all, it was not very expensive when done by means of cast-iron cylinders. The cylinder sank of its own accord at varying rates, on one occasion 10 feet, but afterwards not more than a few inches per day. Whenever the cylinders tended to swing off the plumb-line, an adjustment was effected by building an excess of weight on one side of the cylinder.

Mr. Robert Martin said that the cost was mixed up with the outlays on drains, chimneys, boilers and other things, and it would be difficult to give the cost of the sinking itself. The cylinders cost about £1,000 each. The question of cast-iron as against steel cylinders had been carefully considered, and steel preferred. It was thought also better to put in brick-and-cement walling and less iron, for fear of corrosion. He had studied the conditions of the sinking at Bo'ness, but Mr. Cadell's troubles were all on the surface, caused by the inrush of the tide, and with increase in depth the mud became harder, while at Musselburgh the farther down they went the worse matters became through a big inrush of water, and the control of the cylinders was almost taken out of their hands.

Mr. Roberts (Gorebridge) asked whether Mr. Martin had made any test as to the effects of sea-water on steel and cast-iron.

Mr. Robert Martin said that his experience at Niddrie colliery led him to think that cast-iron would in certain circumstances last longer than steel; but both were subject to rapid decay.

* *Trans. Inst. M.E.*, 1897, vol. xiv., page 237.

Mr. H. M. CADELL said that some of the cast-iron cylinders of the first Tay Bridge had been left lying on the beach exposed to the action of the tide for about 18 months, and the metal was then found to be so rotten in places that the blade of a penknife could be easily pushed through it. Cast-iron cylinders lined with brick and surrounded by clay, which excluded the air, would no doubt resist oxidation much better than if left exposed. The durability of cast-iron after being embedded in sand under sea-water was a subject well worth further investigation.

Mr. JAMES BAIRD (Prestwick) said that about 10 years ago he had sunk a pit somewhat similar to those which Mr. Martin and Mr. Cadell had just described, only neither cast-iron nor yet steel was employed as an outward casing, but simply a brick cylinder, built with cement: the inside diameter was 14 feet and the walls were 18 inches thick. This cylinder was built on the top of a cast-iron leader with a cutting-edge similar to that described by Mr. Martin. The bricklayers built the cylinder from the surface; and with three shifts of sinkers to one shift of bricklayers, it was quite a common occurrence for the brickwork to be left 8 feet above the surface-level at night, and in the morning it would be found level with the ground or even below it. In five weeks, a depth of 70 feet had been reached, and he then found that the cylinder would not descend any farther: however, as the rock-head was not far distant, an oblong shaft was sunk to it, and after a solid foundation was secured the brickwork was built upwards until it reached the suspended cylinder. It was interesting to note that in each of the cases mentioned, the cylinders had stuck when a depth of from 70 to 80 feet was reached.

The CHAIRMAN (Mr. D. M. Mowat) said that Mr. Martin had described a difficult and doubtful operation. The difficulty of the operation was evidenced by the fact that an unsuccessful attempt had been made to sink such a pit near Kilsyth: at a depth of 150 feet the casing collapsed, and the pit was lost. He (Mr. Mowat) approved of the use of a steel cylinder, which was only, however, intended to be a sort of binding for the brickwork. He thought that a steel cylinder would prove more durable than one made of cast-iron, which, when cracked, had not much strength left.

The further discussion was adjourned.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT KEELE, OCTOBER 6TH, 1902.

THE KEELE BORING IN STAFFORDSHIRE.

A few months ago it was decided to determine the continuity, depth and quality of the Red Mine ironstone on the Keele estate, near Stoke, Staffordshire; and the calyx system of boring was selected as most likely to secure the largest and best cores in the shortest time.*

The plant consists of a 60 feet frame-derrick, powerful winding and drilling gear, a 20 horsepower portable boiler with steam-pumps, an engine with 2 cylinders, and an outfit of tools, casing, and appliances.

The boring operations started from the grass with a crown 12 inches in diameter; and after the first string of casing, 12 inches in diameter, was put in to a depth of 80 feet, the succeeding size of crown, 10½ inches in diameter, was producing cores from the Upper Coal-measures, until at a depth of about 300 feet, the whole of the flushing-water escaped into porous and fissured sandstone. As only a limited supply of water was available at the site, casing was inserted to stop the leakage, and this proved successful until another porous layer was encountered. The bore-hole was then reamed down, the casing lowered to a depth of 350 feet, and boring then proceeded rapidly to a depth of nearly 600 feet through Red Marls with occasional hard limestone-layers. To avoid further loss of water, the 8½ inches casing was inserted, and at present the operations are progressing satisfactorily in Red Marls, at a depth of 800 feet with a crown 7 inches in diameter.

The main features of the calyx boring-system may be briefly described as follows:—Hollow boring-rods are attached

* *Trans. Inst. M.E.*, 1898, vol. xv., page 363.

to a tube or core-barrel having a crown, with detachable steel-cutters of special shape and temper, and the upper end of the core-barrel carries the calyx or cup in which the cuttings are stored. A steam-pump forces water through the rods and core-barrel, and raises the cuttings to be stored in the calyx. The boring-rods are driven by gearing, and at such a speed and a pressure as the nature of the strata demands, but generally about one-tenth of the speed of diamond drills; and this evidently has much to do with the preservation of the core and maintenance of the sizes used to greater depths. When the teethed crown does not make rapid progress, it is replaced by another form of crown, applied under a specific speed and pressure, and running on chilled balls, it cuts downward at a good rate. An improved core-tube is used for boring through coal-seams, and ensures the preservation of the core, with greater care and certainty than is generally the case.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE GRAND HOTEL, HANLEY, OCTOBER 20TH, 1902.

MR. W. N. ATKINSON, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. SAMUEL BEATON, Colliery Manager, Cheadle.
Mr. F. FILLINGHAM, Instructor in Engineering and Building-construction, 17, Hamilton Road, Hanley.
Mr. E. M. GOODWIN, Colliery Manager, Landaus Colliery, Brugspruit District, Transvaal, South Africa.
Mr. ALFRED REDFERN, Manager, Natal Victoria Navigation Colliery, Wessels Nek, Natal.

ASSOCIATES—

Mr. SAMUEL HULME, Under-manager, Natal Victoria Navigation Colliery, Wessels Nek, Natal.
Mr. THOMAS YATES, Manager, Brynkinalt Colliery, Chirk.

The Annual Reports of the Council and of the Finance Committee were read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1901-1902.

The Council report that there has been an appreciable addition to the membership during the year: 37 new members were elected as follows:—1 honorary member, 14 members, 1 associate member, 14 associates and 7 students.

The following table shows the membership during the past seven years:—

Year ending.	Life Members.	Honorary Members.	Members.	Associate Members.	Associates.	Students.	Totals
July 31st, 1896.	1	6	120	3	37	16	183
,, 1897.	1	6	116	5	36	19	183
,, 1898.	1	5	112	4	46	14	182
,, 1899.	1	5	106	5	43	13	173
,, 1900.	1	6	108	4	44	12	175
,, 1901.	0	6	130	9	53	22	220
,, 1902.	0	7	140	10	67	27	251

It may be noted, that although 14 new members have been added to the list, there only appears a net increase of 10. This is accounted for by the death, in March last, of Mr. John Hopkinson, of Bowden, and by the exclusion of the names of 3 members, who neglected to pay their subscriptions. In the case of students, 7 new elections only show an increase of 5 in the number, owing to the transfer of a student to an associate and the exclusion of the name of 1 student, who had neglected to pay his subscription.

The names of three gentlemen appear both as honorary members and members, leaving the total number of members at 248, and showing a net increase of 31, equal to about 15 per cent.

During the year, general meetings were held in October, December (2), January, March, May, and a formal meeting in July for the nomination of new members and officers for the ensuing year.

The following papers were read during the year: —

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"Coal-cutting by Machinery." By Mr. R. W. Clarke.

"An Account of the Fitting of a New Drum Shaft to a Winding-engine at Florence Colliery." By Mr. C. V. Gould.

"The Sequence of the Carboniferous Rocks in North Staffordshire." By Dr. Wheelton Hind.

"The Coal-field of New Brunswick, Canada." By Mr. Henry S. Poole.

"Recent Work in the Correlation of the Measures of the Pottery Coal-field, with Suggestions for Further Development." By Mr. J. T. Stobbs.

A discussion on the best method of tightening guide-rods also took place, and a committee was appointed to collect information on the subject. Various other papers were discussed during the year.

An excursion of the members took place in July to the Exhibition at Wolverhampton.

The scheme for providing a College of Science for North

Staffordshire, including accommodation for the Mining Institute had made little progress during the year, owing to a combination of unfavourable circumstances. The chief of these was the death of Mr. A. S. Bolton, the chairman of the Executive Committee of the College scheme, and its most powerful and liberal supporter. Other unfavourable influences arose through uncertainty concerning the proposed federation of the Pottery towns and as to the effect of the Education Bill now before Parliament.

The Council hope that more favourable conditions will arise shortly, and when that time arrives it will be necessary to make a further appeal to the members and to the colliery-owners and other friends of the Institute for further money to carry out the scheme. The subscriptions received for the Building Fund amount to £992 10s. 8d.; and further subscriptions are promised amounting to £454 5s. 0d., making the total sum subscribed and promised £1,446 15s. 8d.

A petition in favour of publishing the recent Geological Survey on the 6 inches map of the Ordnance Survey had been prepared and signatures obtained, and it would shortly be presented to the President and Council of the Board of Education.

The County Council Mining Classes, under the charge of Mr. J. T. Stobbs, were well attended during the past session, and 59 students presented themselves for examination on May 10th last. The County Mining Scholarship was awarded to Mr. T. Johnson, a student of this Institute, at an examination at which there were three competitors.

A prize of £5 5s. has been awarded to Mr. J. T. Stobbs for his paper on "Recent Work in the Correlation of the Measures of the Pottery Coal-field, with Suggestions for Further Development." A prize of £3 3s., offered by Mr. J. C. Cadman for the best paper on any subject by a student, associate or associate member under the age of 25 years, read during the 4 years ending July, 1903, is still open for competition.

During the year, 47 volumes have been bound, and the library has received the usual exchanges. It is gratifying to observe the extended use that has been made of the books, particularly by the younger members of the Institute. We thank our President (Mr. W. N. Atkinson) for gifts of Blue Books issued during the year; and it is earnestly hoped that other members having duplicates of any technical or scientific works will present them to the Library.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee herewith submit their statement of accounts for the year ending July 31st, 1902. The total receipts from subscriptions and arrears amounted to £323 19s. 7d., of which only £274 0s. 6d. was paid for the current year's subscriptions, leaving £69 19s. 6d. unpaid on July 31st last. Of the balance of arrears left over from last year only £23 10s. had been paid, leaving £74 7s. unpaid, making a total arrears account of £144 6s. 6d.

Last year the Committee intimated a reduction in the ordinary expenses of the Institute; and this, it would be seen had now been carried out.

The expenditure on the Library account had been £7 12s. 8d. making a total for that account of £35 4s. 9d. The Committee trust that the members will continue to make the fullest use of the library and reading-room.

The Committee regret exceedingly that the improvement in the prompt payment of subscriptions noted in last year's report, had not been maintained, the subscriptions for the year remaining unpaid amounting to rather more than 20 per cent. It must certainly be to the interest of the members to bring the Institute into a flourishing financial position, but this can never be attained if subscriptions are not all paid promptly. The Committee most sincerely trust that the members from whom arrears are now owing, will make an effort to pay them during this coming year, and avoid the necessity of a similar appeal being made year by year.

The Chairman (Mr. W. N. Atkinson) moved the adoption of the reports.

The resolution was carried.

AWARD FOR A PAPER.

The Chairman (Mr. W. N. Atkinson) handed Mr. J. T. Stobbs a prize for his paper on "Recent Work in the Correlation of the Measures in the Pottery Coal-field, with Suggestions for Further Development."

ELECTION OF OFFICERS, 1902-1903.

The SCRUTINEERS reported the following appointments:—

PRESIDENT:
Mr. A. M. HENSHAW.

VICE-PRESIDENTS:

Mr. G. P. HYSLOP.	Mr. G. A. MITCHESON.	Mr. F. RIGBY.

TREASURER:
Mr. T. ASHWORTH.

SECRETARY:
Mr. F. R. ATKINSON.

COUNCILLORS:

Mr. W. G. COWLISHAW.	Mr. J. R. HAINES.	Mr. J. NEWTON.
Mr. G. J. CROSBIE-DAWSON.	Mr. A. HASSAM.	Mr. T. ROBERTS.
Mr. G. H. GREATBATCH.	Mr. JOHN HEATH.	Mr. J. T. STOBBS.
Mr. J. GREGORY.	Mr. J. LOCKETT.	Mr. T. E. STOREY.

The CHAIRMAN (Mr. W. N. Atkinson), in introducing Mr. Henshaw as the new President, observed that he had always taken a great interest in the progress of the Institute, and would work for a continuance of that progress.

The PRESIDENT (Mr. A. M. Henshaw), after thanking the members for his own election, proposed a vote of thanks to Mr. W. N. Atkinson for his services as President—a position which he had occupied for the past two years.

Mr. R. H. COLE, in seconding the motion, remarked that the thanks of the Institute was due to Mr. Atkinson for the urbanity and courtesy that he had displayed to members on all occasions.

The motion was carried very heartily.

THE TREASURER.

The PRESIDENT (Mr. Henshaw) in proposing a vote of thanks to Mr. Makepeace, the retiring Treasurer, commented on the admirable way in which he had discharged those duties, which were always laborious and often annoying.

Mr. T. E. STOREY seconded the motion, which was carried with applause.

Mr. H. R. MAKEPEACE said that he should not have given up the work if he had not removed from the district.

The PRESIDENT (Mr. A. M. Henshaw) delivered the following address:—

PRESIDENTIAL ADDRESS.

By Mr. A. M. HENSHAW.

If I should seem, in my remarks to you to-day, to fall into the prevailing fashion, and lecture you on the error of your, or rather our, ways, my excuse must be that many of the reproaches of our critics are merited. My purpose is to indicate a few of our shortcomings, so that we may realize them, and take the first step towards reformation. The " decline of Britain's supremacy " has become a stereotyped phrase in the world's press, and from all sides figures and statements are hurled at us to prove our incompetence and degeneracy.

Coming to our own profession, never previously in the history of the coal- and iron-industry of Great Britain has there been a time when those responsible have felt more concern as to its position, present and prospective. Members of The Institution of Mining Engineers and kindred societies are under a microscopic examination by critical eyes, and, distorted and over-magnified as we know the image to be, some real defects are being exposed.

The facts are serious. The United States of America have doubled their output of coal in twelve years, and last year they got ahead of us by 40,000,000 tons. We are invaded by American and German manufactures, iron, steel and machinery. Not only is our foreign trade being taken from us, but we are threatened at our very doors with raw material. Thirty years ago we were producing three times more iron and steel than the United States. Germany has since passed us, and now America beats both combined. We are assailed by enormous outputs, economically produced by great combinations, securing cheap transport by control of railways, owning their own fleets, mainly bought from us, and further assisted by protective tariffs and bounties. Here, we have evidence enough of a serious and determined purpose; and while this is going on, we are pictured as contentedly resting upon the faded laurels of our forefathers, idly dreaming of former greatness.

There are strong grounds for some of these strictures, and there is undoubted need for increased vitality. Let us hope that this treading on the commercial tail of the British lion will have the old-time effect, and that we shall see him awaken the better for his little nap, and once more worry his way ahead of all competitors.

It is still true that great mineral wealth makes a great country, but that greatness is not to be measured in tons any more than it is in square miles, and if we cannot lead in quality and cheapness we must give way. If we fall behind while we have our natural resources, then our coal-fields and iron-works may afford good speculation to our American rivals.

Nothing is more certain to demoralize a man, or a nation than lack of incentive to work, and nothing is better calculated to call up vigorous and healthy effort to excel than straightforward competition. Apart from the effect of American protection and British free trade upon the present position, we must give credit where it is due. It is a mistake to attribute America's progress to her natural resources, which are little better than our own, but it is to her children's good use of those resources, aptitude to meet necessity, energy, hard work, push and ingenuity, pluck in adopting new methods, and appreciation of the best plan and the best man, that America owes her present proud position. It is due to the liberal application by capitalists of money for the equipment of works in a thorough manner with modern plant, and to the hearty co-operation of the workmen who take pride in their work, and are not tied down by prejudice against improvements, or stunted by the levelling influence of the "uniform wage." The State also, as well as the manufacturers and workmen, recognizes the importance of a strenuous commercial policy.

How have we fared at home whilst America has been making these giant strides? Our coal- and iron-trades have been barely remunerative. Sir James Joicey has calculated that for 15 years prior to 1900, the profits in coal-mining were $4\frac{3}{4}$ per cent., without taking depreciation into account. This is a miserable return for so speculative an industry, but it may be pertinently asked whether such results were not the outcome of our indifferent progress and lack of enterprise. We have been moving too slowly, nay, often standing still, and many of our works are to-day being carried on much as they were 25 years ago, with the same

machinery, and by the same methods, even additions and extensions have been on the lines of the old, with second-hand machinery and obsolete plant. We too frequently ask "how much will it cost?" rather than "what will it save?" True we have some of the finest collieries in the world, and one of the Commissioners of the Iron and Steel Trades on his return from America, said that he had seen nothing to compare with a few of the engineering-works which he named in this country; but the majority, and not the exceptions, rule the case in this matter.

Perhaps the most striking contrast between British and American practice lies in their great use of machinery, while we stick to our picks, shovels and wheelbarrows. In many of our pits, particularly, amongst our workmen, there is still the old prejudice against the "iron-man," and the "bone-engine" holds the field.

America is cutting 25 per cent. of its coal by machinery, while Britain does not reach 2 per cent. We have many pits without power-machinery underground, and although in some cases compressed air and electricity are employed to the greatest possible extent, we are on the whole a long way behind. The output of pig-iron, from a British blast-furnace, is 300 to 400 tons per week; but 400 to 500 tons a day is an ordinary performance in the United States and Germany. Costs are even more striking. Foundry pig-iron is being produced in the United States at 34s. and in Canada at 24s. per ton. For seven years prior to the boom, the United States sold its coal at 5s. 1d. per ton, and is now producing it at 4s. 6d., while Canada can put coal on ship-board for European ports at 4s. per ton.

A few years ago, Great Britain was the industrial university of the world, but how are the tables turned! Now we go to America for experts to remodel some of our largest works, and some of our best posts have been given to Americans. Our iron- and steel-trades have sent a Commission to the United States to study their methods, and a Labour Commission is following. Our learned societies go for object lessons to the Düsseldorf Exhibition. Germany gave us coal-washing and coking-plants, and showed us how to recover the valuable bye-products; but we still send thither our crude products, and buy back 90 per cent. of our coal-tar dyes. France and Belgium lead the way in working deep and thin seams. H.M. inspectors of mines find it necessary to hold

up as a model the French system of uniform and safe timbering, and the Dover shafts are being finished by French engineers with French capital, after being practically abandoned by us. These are significant facts and give cause for reflection. We are sinking our pits to-day generally as we did 50 years ago—although some very fine work has been done in this district recently, several shafts, 2,400 to 3,000 feet deep being near completion, and our friend, Mr. J. J. Prest, had, I believe, made a world's record, in pumping up to 8,000 gallons of water a minute, with four 30 inches lifts in one shaft, the work of sinking for months never having been interrupted. For the first time in this country, freezing through water-bearing strata is being carried out in Durham county, although the method had been in successful use in Germany for many years. Boring of shafts is also now practised on the Continent. At the Rheinpreussen colliery, shafts 21 and 16½ feet in diameter have been bored by percussive machines, the borings being brought to the surface by water-column and compressed air, 16½ feet being sunk in one day, and 9 feet a day being averaged for some time.

A large number of pits are being sunk in this country at the present time, and extraordinary extensions of existing coal-fields and discoveries of new areas are as usual following the recent short period of good trade with its attendant panic as to the exhaustion of our supply. The question of deep mining is, in consequence, receiving a good deal of attention, and the depth of 4,000 feet, believed to be the limit by the Coal Commission of 1872, is already exceeded by some, and closely approached by other workings. The Tamarack mine is 5,000 feet deep, the Calumet and Hecla mine 4,900 feet, the workings of several collieries in Belgium reach depths between 3,500 and 3,940 feet, and in England 3,500 feet has been reached in one instance.

The ventilation of deep pits presents no difficulty. Fans giving 500,000 cubic feet with a 6 inches water-gauge are running to-day, and a diameter of 26 feet is all that is necessary for that current. For deeper and more extensive workings, this initial current could be easily exceeded, 30 feet being, according to Mr. C. M. Percy, a sufficient diameter for a fan to produce 750,000 cubic feet of air per minute. This current will be better carried to extreme workings by auxiliary fans, placed under-ground,

dealing with sections of workings beyond the main intake and return airways, than by high water-gauges at the main fan, with the loss by leakage and short-circuiting which would result.

The question of temperature is a more difficult matter: but it will be always less than that due to depth, owing to the cooling produced by the air-current. During the driving of the St. Gothard tunnel, the temperature at times being 107° Fahr., 600 men are said to have died in ten years, but that was largely due to the moisture of the current and climatic conditions. The air-temperature at the Tamarack mine is 87·6° Fahr., at a depth of 4,890 feet; at the Produits colliery 87° Fahr., at 3,768 feet, the rock-temperature being 116·6° Fahr., and in the workings the air-temperature is 96·8° Fahr. Here the men work 10 hours a day in comfort, if the velocity of the air-current be maintained at 5¾ feet per second, owing to the refreshing effect and ready evaporation of the moisture from their bodies. At 100·4° Fahr. with an air-velocity of 5 to 6½ feet per second, it is found that work is performed with greater ease than at 86° Fahr. with a weak current. Means of mechanically cooling the air-current may be found practicable, but it is absolutely necessary that the air should be kept dry. The deepest bore-hole in the world, at Paruschowitz, Upper Silesia, 6,570 feet deep, showed that the rock-temperature increased 1° Fahr. for every 62 feet.

The effect of depth on the degree of hardness of strata is not, I think from experience up to the present, likely to give serious difficulty, or depreciate very greatly the value of the coal-seams.

Winding, on the principle of the present engine, will be a weighty question with a ponderous machine, and calls for improvement. Huge engines, with drums 35 feet in diameter, are now in use at some of our deep pits. Consider the waste of fuel in starting, stopping and reversing once a minute such a drum, weighing upwards of 80 tons, to lift 4 tons of coal. Continental practice is no better, if we may take as an example the new shaft of the Ronchamp colliery, France, which is being fitted with a winding-engine made in Germany. The pit is 3,300 feet deep, and for a trifling load of 2 tons 5 cwts. there are two immense spiral drums, one for each rope, with maximum diameters of 35 feet. The twin-tandem compound engine has cylinders 28 and 40 inches in diameter, and the ropes are tapered from 2¼ inches

to $1\frac{3}{4}$ inches in diameter. I would suggest that the best method is to have high-speed Corliss engines, and to use, in place of the drum, a driving-sheave, which need not be of larger diameter than the head-gear pulleys, grooved for several half-coils of rope, and, in front of it, an idle pulley to take up the coils and admit of length-adjustments of a continuous rope from cage to cage. A tail-rope under the cages compensates the weight of the winding-rope, and an emergency-brake acts on the rope and driving-sheave in case of accident. Several engines of this description have recently been sent out from this country to the Rand, capable of winding $3\frac{1}{2}$ tons from a depth of 4,800 feet. The cylinders are 17 and 28 inches in diameter, at least one-third less than ordinary diameters, and the principle is, I submit, in the right direction towards economy of fuel in the most wasteful of colliery-engines, being equally applicable to shallow as to deep mines.

This question of deep mining belongs more to the future than to the present, but it introduces another subject worthy of a passing remark, namely, the exhaustion of our coal. Deeper working, extended areas of known fields, and the possibilities with improved methods and higher prices, of working thin and hitherto unprofitable seams will, I have no doubt, lead the present Royal Commission to a figure exceeding that of 30 years ago, and we have yet continents to fall back upon whose geological riches are secrets that posterity will unravel. One eminent authority, after allowing for double the present output, placed the final exhaustion 800 years ahead; meantime the present progress of science gives the comforting hope that long before that time posterity will have made itself independent of coal as a source of energy. Our immediate concern is more with economy and auxiliary sources. The question of generating electricity direct from coal is by no means a dream of the idealist. Many years ago, Lord Armstrong obtained distinct results, and the subject has engaged the serious attention of many eminent men, including Nikola, Tesla and Edison, the latter succeeding in obtaining a current of 3 horse-power; while Du Moncel obtained 109 volts at 15·5 ohms from 22 pounds of coke consumed per hour by a Clamond thermopile.

To revert to actualities, we have competitors in the shape of natural gas, oil, wood and peat. The use of natural gas in America needs no comment; of more interest to us is our own

supply. We have in Sussex, a bore-hole (which, by-the-bye, we have allowed an American company to exploit) which is said to be giving 1,000,000 cubic feet a day at a pressure of 200 pounds per square inch. It is lighting the railway-station and village of Heathfield, and the company are taking steps to distribute it largely. It is an interesting venture, but I think that the gas-field is too limited to give results of great importance.

The use of oil as a fuel deserves notice. In America, railways and fleets of steamers are run entirely by oil, and an Admiral of the United States Navy recently said that he expected to see all his ships oil-fired. Experiments on board our own men-of-war show that in heating value, 2 tons of oil are equal to 3 tons of coal, and take only 55 per cent. of the bunker-space, which is an important consideration on any class of ship. A line of Dutch steamships running between Batavia and Singapore using oil for three years, are said to have saved 37 per cent. in cost, as against Welsh coal. Oil is being used on our own eastern and southern railways for express trains of 300 tons; on a consumption of 17·6 pounds of oil per mile, and with coal at 12s. per ton, the former is a real competitor. The world's production of 200,000,000 barrels represents a fuel-valve equivalent to 50,000,000 tons of coal. Oil-engines are thoroughly satisfactory and economical when the cost of coal exceeds £1 per ton, one brake horsepower costing from ¼d. to ⅛d. per hour for oil.

In considering the fuel-supply, our immense tracts of peat must not be overlooked. By modern machinery, a very good briquette is produced, Sweden alone having 300 works in active operation. Wood-fuel also presents possibilities. An ingenious calculation, and one that is believed to be substantially correct, shows that half the present forest-area of the world, if properly cultivated, would yield fuel annually equal to 200 times the world's present output of coal.

So much then for one feature of the question of fuel-supply, but another and more serious one is its economical production and use. The loss underground in working is not now so serious as formerly, but the loss of coal for ever left behind in the shape of barriers between collieries cannot be too seriously regarded. In this district, such barriers are shown to represent no less a loss than £9,787,500 in royalty alone. Then short leases, with

arbitrary rents and royalties, are only too common, and result in the working of thick and profitable seams, the overthrow of the thinner, and premature abandonment and ruin of many otherwise unexhausted collieries. Nothing short of some sort of State-control can stop this waste.

A still more serious waste of fuel is found in the bad use that we make of it even by the best appliances. Less than 10 per cent. of the heat-energy is returned in the shape of work, 20 per cent. goes up the chimney, 20 per cent. is lost in steam-pipes and the engine, and 50 per cent. is still unused when the steam leaves the engine. We are sending, therefore, into the atmosphere, some hundreds of millions of tons of coal a year, getting it needlessly, and using it wrongly. We may certainly hope for wonderful improvements in this direction.

In the coal and iron-industries, steam-power and machinery occupy positions of first importance. We have no Niagaras in Great Britain, we must depend on coal, and yet our collieries have ever been under the reproach of making the least economical use of it, the wasteful figure of 7 per cent. of the output being consumed at our collieries. In first-class steam-practice, we may reckon the consumption per hour per indicated horsepower to be 4 pounds of coal and 35 pounds of steam for an ordinary single-cylindered non-condensing engine, 2¾ pounds of coal and 24 pounds of steam for a condensing engine, 1¾ pounds of coal and 15 pounds of steam for a compound condensing engine, and 1¼ pounds of coal and 12 pounds of steam for a triple-expansion condensing engine. Really first-class colliery practice approximates to 1 pound of coal for 8 pounds of steam, and 20 pounds of steam per indicated horsepower, or a consumption of 2½ pounds of coal per indicated horsepower-hour, which at 4s. per ton would cost 0·0535d. per indicated horsepower-hour. We have recently had figures from actual tests at collieries, showing a consumption of 8·21 pounds of fuel or 53·8 pounds of steam, or at 4s. per ton a cost of 0·1756d. per indicated horsepower-hour. Here is a difference of 0·1221d. Mr. W. N. Atkinson states that there are at North Staffordshire collieries engines aggregating 70,000 horsepower, and at 10 hours a day this difference represents £106,800 a year, which we might save by first-class steam-plant. On the same basis, the saving for the United Kingdom would be £3,417,000. We may say then that the waste of fuel represents

3 per cent. on the capital invested in collieries, to say nothing of the unprofitable employment of labour and plant. In Great Britain, 80,000,000 tons are used annually for power, and many collective tests show a consumption varying from $1\frac{3}{4}$ pounds to 4, 9 and even 20 pounds of fuel per indicated horsepower-hour. On the above basis, with coal and slack at 10s. per ton, I calculate that the present wastage exceeds the enormous sum of £27,000,000.

It may be argued that the standard taken as first-class practice is too high for a colliery, I think not: but, on the other hand, the figure with which it is compared is certainly below general practice. Surely it is as necessary for a colliery to aim at as high a degree of efficiency as a works buying its fuel. I need not remind you how such waste is incurred. Contrast bad boilers, cold feed-water, uncovered steam-pipes, scattered, crippled and old-fashioned engines, with a modern colliery having concentrated plant, mechanically-fired boilers, 30 feet long by 8 feet in diameter, carrying steam at a pressure of 120 to 150 pounds per square inch, water properly treated and heated, superheated steam, compound and condensing-engines, and distant work done electrically. In one colliery-district, the report of H.M. inspector of mines shows that out of 755 boilers no less than 285 are of the old egg-ended type; and how frequently we see badly-designed engines that have never seen an indicator! Probably the highest efficiency ever obtained was at one of the German Universities, where by utilizing the waste-heat of the exhaust-steam to evaporate sulphurous acid and generate pressure in a third cylinder, the steam-consumption was reduced to 8·25 pounds per indicated horsepower-hour. This plan is now being adopted on a practical scale in America. Next in the list, I should place steam-turbines with superheated steam and condenser. They are ideal machines for driving electric generators, and it is worth noting that steam-turbines are being adopted for the electrification of the District Railway in London, several engines of 5,000 kilowatts capacity being proposed.

This brings me to the subject of electricity, which I venture to say is in the modern colliery an indispensable adjunct to economy and efficiency; although the safest of all, compressed air, must be given the first place for much of the underground work in fiery mines, particularly since recent improvements, by stage

compression and intercooling with higher pressures, give an efficiency 40 per cent. better than was obtained a few years ago. Electricity (with some reservation in the case of very fiery mines) is of marvellous adaptability to every requirement in mining. It is economically produced, easily distributed, and its efficiency at ordinary loads may be taken as 68 per cent. in actual work given out by the motor-shaft, the losses being 12 per cent. in the engine, 10 per cent. in the dynamo, 5 per cent. in the line, and 10 per cent. in the motor. In American mines, electricity is in universal use, and latterly, I am pleased to say, has been receiving more attention in this country. A saving of 8d. per ton has been recently recorded at a large north-country colliery by its adoption in a thorough manner. In displacing scattered engines, an economy of 25 per cent. to 30 per cent. may be assured, and in workshops 35 per cent. to 50 per cent. as against belt-and-shaft drives. Collieries are generating current at ½d. per Board of Trade unit, but this figure can be reduced, as I hope presently to show. Its use underground cannot be too rigorously safeguarded, for although with three-phase current, properly insulated and armoured cables, gas-tight junction-boxes and switch-boxes, and enclosed or sparkless motors, safety may be to a large extent assured, there are still grave possibilities of accident. The spark of an ordinary signal-bell will ignite fire-damp; and I feel constrained to say here that the practical study of electricity by those responsible for its introduction does not always receive the attention that it demands. It would be most unfortunate if any indiscretion in its use should result in disaster, thereby tending to check the employment of this most important factor in future economy and efficiency.

Another direction in which we may look for great economy is in the employment of coal-cutting machinery. The output per man in the United States is 82 per cent. more than in the United Kingdom, and this is greatly due to their mining coal by machinery: pits so operated showing more than double our output per man. They use largely the original British machines, but have improved and adapted them to their requirements, and evolved other types. While we employ under 400 machines, they have 3,500 in regular work, and when we see outputs of 1½, 3 and 3½ tons per man increased to 4, 6½ and 8½ tons, and savings of 4d. to

over 1s. per ton effected, we cannot afford idly to wait and doubt. These are results that we see in our own collieries, and it is surprising that so many, with conditions admirably suited to machinery, are doing absolutely nothing in this direction. It is unfortunate in North Staffordshire that many of us have to struggle on under conditions which render the use of any machine, so far produced, impracticable. Seams lying at angles of 30 to 50 degrees with as many faults as roadways, present almost insurmountable difficulties to the successful introduction of coal-cutting appliances.

A most important advantage following the use of such machinery is the abolition or minimizing of blasting, and in this connection I must refer to the hydraulic wedge shown to the members by Mr. James Tonge a few years ago,* for which he has received the Society of Arts prize and medal. I have seen a man with this machine getting 30 shots a shift with his can of water instead of a canister of explosive, and we appear to have, at last, a really practicable tool.

Turning to our iron-industry, let me say a few words regarding another serious waste—that of the gases from our blast-furnaces. The blast-furnace is a gas-producer of the highest order, its inherent heat doing the work of melting the ore, and generating at the same time 160,000 to 200,000 cubic feet of combustible gas per ton of fuel consumed. The gas has a heat-value of about 100 British thermal units per cubic foot, and 100 to 120 cubic feet in a gas-engine will give 1 horsepower. The gas-engine is now a thoroughly practical, reliable and simple machine. We have 70,000 engines working in this country, chiefly with illuminating or producer-gases. But on the Continent, extraordinary progress is being made, engines of 1,500 horsepower working with blast-furnace gas, and others of 2,000 and 4,000 horsepower will soon be running, although only two years ago, at the Paris Exhibition, a 600 horsepower engine created great surprise. At one iron- and steel-works in Germany, the furnace-gases are driving nine gas-engines, aggregating 5,400 horsepower; and at another, there are several engines of 600 and 1,500 horsepower generating electricity at 550 volts, supplying 64 motors at the steel-works for rolling-mills, locomotives, cranes, hoists, and mechanics' shops, and lighting 240 arc-lamps and 400 incandescent-lamps. In this

* *Trans. Inst. M.E.*, 1898, vol. xv., page 269.

country, only two or three works have attempted to employ gas in this way, the majority being content to use it under the boilers, the bulk going to waste, although 100 feet in a gas-engine will give as much power as 400 feet used for raising steam.

Here is a calculation applied to a furnace producing 300 tons of iron per week. The consumption of fuel taken at 1·875 tons per hour would give 303,535 cubic feet of gas, of which one-third would be required for heating the stoves, leaving 197,357 feet for power. Allowing 10 per cent. loss on the total gas, the power-quantity would be 167,004 cubic feet. Taking the heat-value of the gas at 95 British thermal units, and the engines requiring 140 cubic feet per indicated horsepower, and 152 horsepower for the blowing-engines and hoists, there would remain 1,040 horsepower as a continuously available surplus-power.

I will take, however, a lower figure, given by one of the presidents of the Iron and Steel Institute, namely, that for every 100 tons of pig-iron made per day, the surplus gas represents 1,000 horsepower. Applying this to North Staffordshire, assuming that all our 28 blast-furnaces were at work and producing 600,000 tons of iron per annum—certainly not an unreasonable figure—and allowing 32 per cent. for loss by conversion and distribution as electrical energy, we should have a continuous current of 13,600 electrical horsepower. Now Mr. W. N. Atkinson states that we have at our collieries, engines of 30,000 indicated horsepower doing work other than winding coal, this at 10 hours a day at full work would be equal to 12,500 horsepower continuously over a cycle of 24 hours, so that it is evident we should have from our 28 blast-furnaces a surplus power, if taken continuously, equal to doing all the work at our collieries except winding coal. This current if sold at ½d. per Board of Trade unit, would be worth at 10 hours a day, £65,875 a year, or if for power and lighting for 20 hours a day, £131,750 a year; and to the commercial mind these figures bring visions of dividends. Proportionately, the 350 blast-furnaces now working in the United Kingdom, would give a continuous current of 170,000 electrical horsepower: the whole of the collieries requiring for 10 hours 990,000 horsepower, or the equivalent of 410,000 horsepower continuously. We must, therefore, look for an additional source of supply. We shall find it in our coke-ovens, where there is a similar waste calculated at 251,600 electrical horsepower. Together then, we should have a

surplus of 421,600 electrical horsepower, which if taken continuously would be equivalent to the power required by all the collieries in the United Kingdom, except for winding coal. At ½d. per Board of Trade unit for 10 hours a day, the current would realize £2,039,800, and for 20 hours a day £4,079,600 per annum, and this is now being wasted. I have in these figures merely brought in the collieries to give point to the case, and it is not necessary for me to show how this surplus-power could be utilized. On the Continent, its importance is well understood, and the savings are realized in the shape of hard cash in pocket.

Coincident with the development of the gas-engine, producer-gas is asserting its claims to a first place in the economics of power-generation. Compared with steam-plant, the gas-producer returns 75 to 80 per cent. of the thermal value of the coal, or practically the same as a steam-boiler; but the gas-engine returns 15 to 30 per cent. of thermal efficiency, or twice that of the steam-engine with 5 to 15 per cent. of thermal efficiency. As fuel only, producer-gas takes a high place. Under steam-boilers, 8 to 10½ pounds of water are evaporated per pound of coal in the producer; and in steel-works it may be almost said that modern processes owe their existence to producer-gas. We will consider it, however, more in connection with the gas-engine. Its thermal value varies from 135 to 160 British thermal units per cubic foot, and 140,000 to 160,000 cubic feet of gas are generated per ton of fuel, 60 to 80 cubic feet being consumed per indicated horsepower in the gas-engine, or we may say 2,000 horsepower per ton of fuel, 1 pound of fuel being a safe basis to take as the consumption in a good plant per indicated horsepower-hour.

At the Tees-side engineering-works, monthly returns show 0·89 pound of fuel per brake horsepower. At Leyton electric power-station, 0·942 pound per indicated horsepower; Uxbridge, 1·067 pounds; Winnington chemical-works, 0·92 pound: Paris, with French coal, 0·81 pound; and Zurich, 1·22 pounds of fuel per indicated horsepower. At Winnington, a Premier gas-engine of 600 horsepower showed an average over two years of 1·05 pounds, but at times attained the low figure of 0·88 pound of fuel per indicated horsepower-hour—the same engine running 138 days without stopping. The use of producer-gas is much more general on the Continent than in Great Britain, the Anzin colliery, France, putting down just now producer-plant for all its work except winding.

The late Mr. Bryan Donkin, whose great experience and ability commands our confidence, reduces the subject to the cost per horsepower of work done.

Description of Plant.	Fuel.	Cost of Fuel.	Cost of Fuel per Brake Horsepower.
			Pence.
Illuminating-gas and engine ...	Gas	2s. 3d. per 1000 cubic feet	0·636
Oil-motor	Oil	6d. per gallon	0·502
Steam-engine	Slack	7s. per ton	0·151
Producer-gas and engine ...	Coke	15s. ,,	0·137
,, ,, ...	Coal	14s. ,,	0·095
,, ,, ..	Slack	7s. ,,	0·047

The fuel-cost only is taken in the above figures, and if we calculate on a consumption of 1 pound of fuel per indicated horsepower-hour, and take slack at 5s. per ton, the cost would be 0·026d. I will take, however, for, say a 500 horsepower plant, 1¼ pounds of slack per indicated horsepower-hour. The cost would be: fuel, 0·032d.; wages, 0·024d.; and stores, 0·012d.; a total of 0·068d. per indicated horsepower-hour. If we generate electricity, and put the mechanical efficiency of the gas-engine at 85 per cent. and dynamo at 90 per cent., or total combined efficiency of 75 per cent., the cost would be 0·09d., or say 0·1d. per electrical horsepower-hour, or 0·14d. per Board of Trade unit. If we make further allowances, and put the cost at 0·20d. per Board of Trade unit, the cost per annum for fuel, wages and stores of a 500 horsepower plant will be under £2,000, a figure so surprisingly low as to arrest our attention, and set us considering the possibilities of economy by adopting power-gas. There will be no economy in taking power from central stations. Any colliery may have its own plant, the gas being preferably distributed for surface-work, and electricity used for distant and underground work.

I had intended to refer to other possible economies relating to work underground; and, in connection with our difficulties in meeting American competition, to compare our respective railway and transport-facilities, but time will not permit. I trust however, that what I have said may suggest to the members subjects for papers and profitable discussion during the short time that I shall have the honour to occupy the Presidential chair.

I have repeatedly referred to America, because there is no disguising the fact that there lie some of the secrets of our failure, and a glance in conclusion at some of their achievements may be calculated to spur us ahead. The following figures dwarf British practice. Three steam-shovels mine 5,000 tons of ore, and load it into 50 tons trucks in 10 hours; and 2,000 of these shovels will do the work of 4,000,000 men. The ore is carried in train-loads of 4,000 tons at ⅛d. per mile, and a vessel of 6,000 to 7,000 tons is loaded in 10 hours. The cargo is discharged, and the steamer is bunkered and ballasted in 10 hours, or the ore may be dumped from the trucks into huge storage-docks holding 40,000 tons, from which a 7,000 tons steamer can be loaded in 3 hours: indeed the record is 5,000 tons in ½ hour. The cost of loading or discharging such a vessel is about ½d. per ton, and the whole operation is effected by automatic machinery. The ore is as expeditiously stocked on the ground, or in storage-bins at the furnaces, by travelling-bridge tramways, 300 to 400 feet long, and 70 feet overhead, operated electrically, and one man can handle 2,000 tons a day. Two or three men will attend to the machinery delivering the ore, coke and limestone to the blast-furnace, and 400 to 600 tons of iron per day will be run from each blast-furnace. At the Carnegie works, the No. 3 Carrie blast-furnace has made in one day 790 tons of basic open-hearth iron. From the blast-furnace, the molten metal is taken to the steel-plant through the mixer, converter, blooming-mills and rolls, and is turned out as finished steel in practically one heat. From one works with two mills, 2,914 tons of finished rails have been made per day. At another, 2,000 tons of plates, and at another 3,500 tons of girders; while from another works, as a small detail, 600 tons of rods were turned out for wire-nails; and if you want nails, the Ensley works with 171 machines will turn out 1,500 tons a day. In 10 years, the output of pig-iron has doubled, and finished products has trebled. The output of pig-iron per man has increased in 10 years by 29 per cent. and of finished iron and steel by 37 per cent.

In 1900, and here is the main point, the average output of pig-iron per man per annum employed at blast-furnaces in the United States was 354 tons, and at the Duquesne works, it was no less than 1,300 tons.

Canada, too, is forging ahead; she has outgrown her own

demand and is producing 20 times the amount of iron that she did 5 years ago. Two years ago, the Dominion Steel Company laid their first brick ; their blast-furnaces have turned out already 10,000 tons, and they have now a plant with a capacity of 500,000 tons a year. Germany has proceeded much on the same lines. Blast-furnaces turning out 400 to 500 tons a day are becoming the rule; they concentrate their plant, own their own coal-mines, ore-mines and coke-works, get their ore and handle it by machinery on a great scale, take their iron direct to the steel-plant, the whole power being derived from the waste furnace-gases. The result of this enterprise is that their output per man has trebled in 20 years.

These are some of the conditions that we have to meet in our fight for trade. Mr. Schwab says that they must export their surplus, and to keep prices up at home they will sell that surplus at a loss rather than decrease production. It is calculated that Alabama foundry-iron can be delivered, now, as ballast in our cotton-ships, at Manchester for 50s. per ton and will shortly be delivered at 10s. less, and New Jersey iron at Liverpool at 44s. per ton. With their 24,000,000 tons capacity, and the new blast-furnaces building for several millions more, we shall need to watch vigilantly if times of depression come and demand falls off. There may be something in the American argument that combinations expand trade and create new revenues by reducing the cost of its commodities. This indeed appears to be borne out by the fact that the consumption of iron and steel is five times greater per head of population in America than the average of other countries, but the danger of over-production seems ominously threatening.

If we can compete in raw material, we need not despair of finished products and we are nearer to the European, Eastern and Southern markets than our Transatlantic competitors. We have still large supplies of ore at home, and Spanish and other ore, nearer than is the American ore to their furnaces, but we must keep up to date if we would still remain ahead. Reform must be initiated quickly and vigorously, for we have scarcely as yet realized the rapidity of the progress of our rivals. The crisis calls for men of alert mind, abundant energy and scientific training, with a grasp of every aspect of the question. It is true that

many of their works are new while ours are old, but that is the very reason why we should scrap our plant and rebuild our works on modern lines. It will not pay in some instances, and here again is the need for men of great discrimination and ability, but in other instances it will pay to do it thoroughly and expeditiously. The fittest must survive, and the battle must be to the strong. Edison recently said that if Great Britain would wake up to American competition, the result would be the greatest battle of wits that the world had ever seen. Then by all means let us give the world the spectacle. Members of this and kindred societies will be called upon, and will do a big share of the fighting. We have the sinews of war; the bed-rock of sterling national qualities that gave us our world supremacy is still our inheritance, and I fully believe that in the long and tough struggle ahead of us, Britain once fairly roused will more than hold her own against the world.

Mr. E. B. Wain moved a vote of thanks to the President for his address.

Mr. W. N. Atkinson, in seconding the motion, observed that the address struck the imagination, and should spur the exertions of all who had to do with the production of coal and iron in this country. He was not himself inclined to draw very positive conclusions from comparisons made of work done in different countries. What was wanted in this country more than anything else was that scientific education should be brought to bear upon the management of coal- and iron-works.

The motion was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, OCTOBER 11TH, 1902.

SIR LINDSAY WOOD, BART., PRESIDENT, IN THE CHAIR.

The SECRETARY read the Minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 16th, September 27th and that day.

The SECRETARY also reported the proceedings of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

MR. JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.

MR. ALFRED QUINTIN CARNEGIE, Engineer, 21, Eldon Place, Newcastle-upon-Tyne.

MR. CHARLES CROFTON, Engineer, 17, Albany Gardens, Whitley, R.S.O., Northumberland.

MR. PERCY H. JONES, Colliery Manager, Snatchwood Park, Pontypool, Monmouthshire.

MR. ROBERT RUTHERFORD, Colliery Manager, Axwell Park Colliery, Swalwell, R.S.O., County Durham.

MR. HERBERT KILBURN SCOTT, Consulting Mining Engineer, Clun House, Surrey Street, Strand, London, W.C.; and Rio de Janeiro, Brazil.

MR. ROBERT ROWELL SIMPSON, Mining Engineer, The Geological Survey of India Offices, Calcutta, India.

MR. WILLIAM SMITH, Mine Manager, The Buffelsdoorn Estate and Gold-mining Company, Limited, Klerksdorp, Transvaal.

MR. JOHN WHITFIELD THOMSON, Mining Manager, General Manager, Ashanti Proprietary Gold-mines, Limited, c/o Messrs. A. Miller Brothers, Axim, Gold Coast, West Africa.

ASSOCIATE MEMBERS—

MR. GEORGE MAITLAND EDWARDS, 24, De Vere Gardens, West Kensington, London.

MR. OSWALD W. ELLIS, 31, Grosvenor Place, Newcastle-upon-Tyne.

MR. CHARLES R. PATTINSON, Burnaby Lodge, Ryton-upon-Tyne.

ASSOCIATES—

MR. JOHN ESKDALE, Assistant Mechanical Engineer, Ashington Colliery, Morpeth, Northumberland.

MR. WILLIAM JAMES KNIGHT, Engineer's Draughtsman, 12, Wolmerhausen Street, Wheatley Hill Colliery, Thornley, R.S.O., County Durham.

MR. GEORGE BAILEY MORRIS, Back-overman and Surveyor, 7, Lloyd Street, Lemington-upon-Tyne.

MR. PERCY EDMUND SMALLWOOD, Back-overman, Chopwell Colliery, Lintz Green, R.S.O., County Durham.

MR. JAMES WALLACE, Gold-miner, c/o West African Union Mines, Adjah Bippo, Tarkwa, *via* Sekondi, West Africa.

STUDENT—

MR. JOHN EDWARD RALPH HERRISON, Mechanical Engineering Apprentice, Ottawa, *via* Durban, Natal, South Africa.

DISCUSSION OF MR. FRED C. KEIGHLEY'S PAPER ON "COKE-MAKING AT THE OLIVER COKE-WORKS."*

MR. A. L. STEAVENSON (Durham) said that the coke-ovens described were of the old type of bee-hive ovens similar to those working on the Quayside, Newcastle-upon-Tyne in 1765, and which he himself had described to the members of the Institute in 1860. Mr. T. Y. Greener† appeared to agree that the 12½ feet coke-oven described by Mr. Keighley was an improvement on the practice in the North of England of erecting 11 feet ovens. He (Mr. Steavenson) differed from Mr. Greener on that point, for if the ovens were 12½ feet, and the drawers had to work with drawing-rakes sufficient to reach to the back of the oven, they became exceedingly heavy and awkward to move, and one of the first results would be that the workmen would demand an increase of 1d. or 2d. per oven. In his experience, a coke-oven 11 feet in diameter was about the best dimension to adopt. In building the ovens described by Mr. Keighley, no space appeared to have been left between them; and, consequently, there was no room for the expansion of the ovens, which would eventually mutually destroy each other. Mr. Greener pointed out that it was wrong

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 493; and vol. xxiii., page 485.

† *Ibid.*, vol. xxiii., page 485.

to use lime in the building of the ovens, but what was described in the paper was loam-mortar, and he (Mr. Steavenson) understood this to mean the use of loam instead of lime-mortar. The cost of manufacture was a little above that of this district, namely, 1s. 7½d. against 1s. 5d. to 1s. 6d. per ton; wages, however, were high, and he was not surprised at the cost being a little more. The paper described a seam of good coking coal, and under such conditions it was not surprising that the coke was obtained cheaply, and it was no fault of the managers of collieries here that they could not compete with them in price,

It was stated in the paper that no attempt had been made to utilize the waste-products, and in this respect America is very far behind this country. He (Mr. Steavenson) did not go so far as Prof. P. P. Bedson, who contended that they were bound to extract from the coal every product which it was capable of yielding. To put down a plant capable of extracting bye-products from 700 coke-ovens would involve an outlay of £90,000, or more than twice the cost of ordinary bee-hive coke-ovens. Before entering upon such a very large outlay, it was necessary to consider whether the bye-products would justify the expenditure, and it would be seen by referring to an article on "Coke-oven Residuals"* that some of these bye-products had a very limited market, and had recently experienced a very serious fall in prices. He had supplied blast-furnaces with coke from bee-hive coke-ovens for the last 50 years, and during that time he had been at least once a week to the furnaces, and therefore knew exactly what kind of coke they wanted. He found that if they used coke from retort coke-ovens, 2 cwts. more of such coke were required per ton of iron than of coke from beehive coke-ovens. Many engineers had experimented with a few retort coke-ovens, but they were generally very shy of giving their results; and merely contented themselves with stating that the coke was just as good.

With 28 beehive coke-ovens, they could boil, with a Lancashire boiler, 80 tons of water in 24 hours. Assuming that this quantity of water was boiled by coal, it would be found that this alone represented something like 1s. per ton of coal put into the oven, and this he contended was a very useful mode of utilizing what might be termed a bye-product. At three large collieries

* *Colliery Guardian*, 1902, vol. lxxxiv., page 360.

raising about 1,000 tons per day, they were using no coal whatever for their boilers, and he would defy anybody to come forward and say that retort-ovens were giving better results than this; taking into account, in the case of retort-ovens, the extra cost per oven for distilling the bye-products, and the great doubt there was as to the value of the material compared with the known value of the gases used under the boilers.

Mr. F. R. SIMPSON suggested that in all papers of this kind it would be an advantage if the unit of weight was the ton of 2,240 pounds. The special feature in the plant of beehive coke-ovens described was the low cost of producing coke, due chiefly, as Mr. Steavenson had pointed out, to the low cost of the coal. Reducing the figures to the British ton, the total cost amounted to only 7s. per ton. Taking the yield of coke at 67 per cent., the coal put into ovens only cost about 3s. 3d. per ton, a very low figure. The cost of labour in converting the coal into coke, was about 1s. 9d. per ton, or slightly higher than the cost at many coke-yards in the North of England, and this was accounted for by the higher rate of wages paid to the men. The cost of materials was low, being about 0·80d. per ton of coke produced. The average coke-production per day from 300 ovens drawn was 675 to 700 short tons, or 603 to 625 long tons; and at the rate of three drawings of each oven per week, this gave 12½ tons per oven per week, a result which could only be obtained by regular working. Messrs. Oliver supplied the coke to their own blast-furnaces, and any small variations in the quality would be treated with greater leniency than in the open market. Over 9 per cent. of ash, on the average of the analyses, appeared high when the whole output was converted into coke, and many collieries in Durham could manufacture coke from small coal with the percentage of ash quite as low.

The statement that the establishment of 700 beehive coke-ovens was until recently the second largest in the world, was rather sweeping, and might perhaps be modified into an expression of opinion.

Mr. J. C. B. HENDY (Etherley) said that all who had read Mr. Keighley's paper would agree that the writer had every reason to congratulate himself upon the nature and quality of the coal that he had to coke. A coal which could be thrown into

the ovens as it came out of the mine, without any cleaning, crushing or any treatment whatever, and yield 67 per cent. of coke which only contained about 9 per cent. of ash and 0·7 per cent. of sulphur, was very valuable, especially if it could be put into the coke-ovens at a cost of 4s. 4d. per ton. The Connellsville seam is naturally an excellent coking coal, but when we come to consider the manner in which it is treated and the construction of the coke-ovens described in the paper, there are several points which are open to discussion.

Setting aside the question of the recovery of the bye-products, there is apparently at the Oliver coke-works no attempt whatever to utilize in any way the waste-gases from the ovens, either for raising steam or any other purpose. The ovens are burnt out of the top-eye. There may be some special reason for it, not explained in the paper, but it is rather surprising to find, in such a large plant and where so much money has been expended, that there is no arrangement of flues to the ovens. He (Mr. Hendy) thought that if a properly constructed main flue had been made between the rows of ovens, with branch flues from each oven into the main flue, and dampers so arranged in the branch flues that the coke-burner could regulate the proper proportion of air-supply to each oven and shut off the oven from the main flue when necessary, a much better and more economical result would have been obtained.

The ovens appear to have been built (in the first instance) of ordinary fire-bricks, which after about 4 or 5 years have fallen in, partly owing, no doubt, to the poor quality of the bricks and partly to the construction of the oven. Mr. Keighley also appears to have used a brick made of flint-clay containing about 64 per cent. of silica and 26 per cent. of alumina, but he (Mr. Hendy) could not make out from the paper where these bricks had been used. The latter is evidently a mixed brick, or a brick made of a mixture of clays yielding together the above proportions of silica and alumina. Mr. Keighley is now, however, using a brick containing about 97 per cent. of silica. Such a brick, no doubt, is eminently suitable for very high temperatures, but he (Mr. Hendy) doubted whether it would stand the constant heating and cooling to which a coke-oven was subjected, and he believed that if the coke was slacked in the oven, the water and steam would have the effect of cracking this brick and causing it to splinter and fall

into the oven in small pieces. He (Mr. Hendy) was of opinion that the best brick for use in building beehive coke-ovens contained about 70 per cent. of silica and 23 per cent. of alumina, and was made from a clay naturally yielding of itself these proportions of silica and aluminia. He had known several instances of such a brick lasting in beehive coke-ovens for 20 to 25 years: of course the back-eyes and door-jambs had been repaired during that time, but the body of the coke-ovens had stood for that period.

He (Mr. Hendy) agreed with Mr. Steavenson that a diameter of 11 feet was the most convenient and useful size for a beehive coke-oven.

In the ovens at the Oliver works, the doors were only 2 feet 8 inches wide and 2 feet 8 inches high to the spring of the arch; he thought that this door was rather narrow for a 12 feet oven, and that the drawer might experience some difficulty in drawing out the coke from the sides of the ovens.

Further, it would be noticed that there was only one line of rails running along the centre, for loading both rows of ovens—an objection to only one line of rails was, of course, that the ovens could not be loaded so quickly as with two lines, and that if a stoppage or breakdown occurred on the only line, the loading was stopped on both rows of ovens. He preferred a line of rails running over each row of ovens, with a lighter and smaller locomotive and smaller coal-tubs.

A striking feature in this paper was the low cost of production compared with the rate of wages paid for coke-making. He noticed that chargers were paid 7s. 8d. per day; ash-carters, 6s. 8d.; track-cleaners, 6s. 3d.; car-shifters, 9s. 4d.; masons, 10s. 5d.; and labourers, 6s. 3d. The cost of the coal put into the ovens was low, but something more than this appeared to be necessary to account for the low total cost of coke-production, when the above rates of wages were considered; and it would be interesting to know the number of hours and amount of work done per day by the above workmen, and compare the same with those prevalent in this district.

Mr. Keighley had told the members that he had sold coke for 2s. 11d. per ton. They were accustomed to hear of startling things from America, and, certainly, the most extraordinary selling-price that he had heard of for blast-furnace coke was 2s. 11d. per ton.

Mr. W. C. Blackett (Sacriston) thought that it was remarkable that so little account was taken, in comparing the different kinds of coal, of the temperatures at which the coal carbonized. One gentleman, who found his coal, carbonizing as it did at a high temperature, to be best suited for a beehive coke-oven, would condemn another for using retort-ovens, although the latter might be better adapted to his particular class of coal, which coked at a lower temperature. A colliery-owner might be driven at last to work an inferior seam, and from bye-product ovens, he would obtain as good, and sometimes better, coke than he would obtain, perhaps, from the same coal burnt in bee-hive ovens. In bee-hive ovens, their fine Durham coal carbonized at a very high heat, and when they had a very high heat they got a deposit of carbon—similar to that in gas-retorts—upon the coke, giving it a fine silvery and hard looking appearance. Some of the inferior coal did not carbonize at that high heat, and they did not get the same fine crystalline appearance and the same hardness, and it was comparable with the black-looking coke, watered outside, produced at bye-product ovens.

Mr. W. O. Wood (South Hetton) wrote that, judging from the particulars given in Mr. Keighley's paper, coke-making was one of the things that could be done better in England. From a coal, containing 5·73 per cent. of ash, the resulting coke ought to contain 8·12 per cent of ash, and the 9·25 per cent. was no doubt due to the fact that "no cleaning or slate-picking is done." Iron-masters in this country would certainly not be satisfied with a coke containing so high a percentage of ash. The yield appeared to be fairly good, and the breeze was apparently wasted.

Without knowing the country, it was difficult to judge, but unless the region was very arid, the supply of water necessary for cooling the ovens could have been collected in reservoirs at a very small proportion of the cost of the pipe-line, 12 miles in length, to say nothing of the cost of pumping the water.

The President (Sir Lindsay Wood, Bart.) said that Mr. Blackett had raised an important point respecting the temperatures at which coal was carbonized, and this would make a considerable difference in the results obtained from the ovens.

DISCUSSION OF MR. E. REUMAUX'S PAPER ON THE "USE OF WASTE-GASES FROM BYE-PRODUCT COKE-OVENS IN EXPLOSION-MOTORS."*

Mr. W. M. Parrington (Wearmouth colliery) wrote that he considered Mr. Reumaux's deductions as to the desirability of using the waste-gases from coke-ovens for power purposes were unanswerable. Mr. Reumaux clearly showed that at a large colliery, coking, say, half its output, as much power could be got by using the waste-gases in explosion-motors as would meet all the requirements of such a colliery under average conditions as to depth, water to be pumped, etc.

Mr. B. H. Thwaite (Westminster) wrote that Mr. Reumaux's paper was interesting and important, because it brought forward a subject that deserved the serious consideration of all owners of coke-ovens. If one were asked to provide an expression to signify in the briefest possible way the particular element that was supremely essential to a manufacturing nation, no better reply could be given than is embodied in the sentence "cheap and abundant fuel-power." Therefore, the question of utilizing the waste effluent gases from coke-ovens for the purpose of securing directly or indirectly this supreme essential assumed at once a position of first-class importance.

The production of power for any modern electrical industry likely to be of permanent value, should be abundant. The fuel should be such as to permit of its being used for the production of power in large units, and it should be of such regular composition as to permit electric machinery to be driven by it. The effluent gases from coke-ovens, however, do not provide either condition satisfactorily. The hydrocarbon-constituents of coke-oven gas are extremely variable, and independently of their variability, they are too sensitive to combustion influences to permit of a satisfactory thermo-dynamic efficiency being obtained. Further, the power-potential as given by Mr. Reumaux, is not sufficiently large to permit of the laying-down of electric apparatus of sufficient magnitude to satisfy the creation of an electrical industry.

He (Mr. Thwaite) had two distinct methods of securing the most profitable use of the coke-oven effluent gas, and by these the objections raised were removed. One method was to dilute the effluent gas from the coke-ovens, with four times its volume

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 402.

of generator-gas, containing no appreciable proportion of hydrogen, but having as its combustible constituent from 25 to 30 per cent. of carbonic oxide, such gas being generated from poor coke unsuitable for sale at a fair price. This method at once secured such a reduction in the proportion of the hydrocarbons, that the composite gas could be used for driving gas-engines of 1,000 horsepower and with satisfactory cyclical regularity. The indicated horsepower of the gaseous effluents issuing from each unit coke-oven, would be raised from Mr. Reumaux's factor of 15 to that of 63¾ indicated horsepower, so that a battery of 120 coke-ovens would have a power-potential of 7,650 indicated horsepower. This magnificent power-aggregate would only involve the putting on one side of 3·4 tons of poor coke, and this residue would be used to the best possible advantage.

Where coke-ovens were associated with blast-furnaces, his (Mr. Thwaite's) second method was the best. This included the employment of the coke-oven gases as directly as possible for the purpose of firing the hot-blast stoves, for the purpose of setting free blastfurnace-gas for the production of power in gas-engines. He had demonstrated that blastfurnace-gas was, as nearly as possible, ideal for power-production purposes, and the use of coke-oven gas in hot-blast stoves would enable a higher and more equable stove-temperature to be maintained, because no lime or other incombustible matter would be introduced into the stove with the gas; and although blastfurnace-gas was so ideal for producing power, it was nevertheless inferior to coke-oven gas for heating purposes in which combustion was effected in fire-brick stoves or furnaces.

It would be noticed, on referring to the table of data supplied by Mr. Reumaux* that he gave the electrical horsepower ratio in No. 1 experiment as being equal to 16·42; this he (Mr. Thwaite) thought should be 15·33. In No. 2 experiment, Mr. Reumaux gives the figure as 17·10, but this he (Mr. Thwaite) also thought should be 16·85.† The variation in power would thus be (16·85 − 15·33 =) 1·52 electric horsepower, resulting from the variable hydrocarbons present in the gas. This constituted a very serious variation, and one that was quite inadmissible where the motive power had to be harnessed to electric generating machinery.

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 404.

† An electrical horsepower is 736 Watts in France, and 746 Watts in Great Britain.—EDITOR.

DISCUSSION OF MR. G. P. LISHMAN'S PAPER ON "THE ANALYTICAL VALUATION OF GAS-COALS."*

Mr. W. C. Blackett expressed his appreciation of Mr. Lishman's paper. He thought that analyses of gas-coal were often unfair and unreliable, and not unfrequently cargoes would be condemned because a few pounds, or it might be grains, of coal had given unsatisfactory results in the laboratory.

Mr. H. Dunford Smith (Newcastle-upon-Tyne) complimented Mr. Lishman upon the apparatus, which had been adopted at the Lambton collieries. He considered the plan of water-jacketting the condensers a very good one, and wished that it was universally adopted. From 60 to 90 minutes seemed to be rather a long time to be occupied in making a test: he thought that 45 to 50 minutes should be long enough, and he would like to know whether the additional time made any difference in the sperm-value.

Dr. H. S. Pattinson (Newcastle-upon-Tyne) wrote that this paper, dealing as it did with difficulties encountered in the testing of coal on a small laboratory scale to determine its value for gas-making purposes, was chiefly of interest to those whose business it was to make such tests. The value of these tests, of course, depended upon how they compared with the results obtained on the working scale in gas-works. If it was found by experience that the laboratory-test bore a definite ratio, within reasonable limits, to the result obtained when the coal was used in the gas-works, then the laboratory-test had a high value. Although there was some difference of opinion on the subject, yet he thought that it might be taken as generally conceded by gas-works managers and chemists that tests on a laboratory-scale of a coal formed useful guides as to the illuminating-value of the coal. It had been found by experience that the results given by a coal on a gas-manufacturing scale were inferior to those obtained from the coal in a coal-testing apparatus; but the difference between them had been found, within reasonable limits, to be fairly constant, so that a gas-works manager from his own experience might ascertain what deduction from the sperm-value of a coal given by the laboratory-test had to be made, to shew him what the coal would yield him industrially. Anything that would

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 567.

assist us to obtain regular results in laboratory-trials was of interest and value, and the members were indebted to Mr. Lishman for giving them the benefit of his experience.

The difficulties in the way of obtaining regular results he rightly points out to be due:—(1) To variation of the heat of the distillation-retort, and (2) to the effects of the changes of temperature upon the condensable products of the gas in the tar-condensers and purifiers. He (Dr. Pattinson) had not found the first of these to offer great difficulty. A fair measure of the heat was the time required to expel all the gas, and by allowing a certain time for expelling say 10 to 10½ cubic feet from 2¼ pounds of coal, and adjusting the heat so as to drive off the gas in that time, the temperature of the retort might be taken to be fairly constant. With regard to the second point, he was surprised to learn that in Mr. Lishman's experience he still obtained very variable results, when the external heat around the cooling-pipes and purifiers and in the gas-holder was maintained constant by artificial means. Mr. Lishman offered no explanation of this and he could see no obvious one.

Mr. Lishman's remedy for all irregularities was to make a comparative test of each sample with a "standard coal" obtained from a "standard seam," and proportionately as the results obtained with a standard coal varied from the normal, he made a correction upon the results given by the sample. He took no objection to the principle of correcting by a standard, but it was not every one who had a "standard coal" or a "standard seam" always available. And, he might be permitted perhaps to add, that knowing how the coal in most seams varied from time to time, he would feel very doubtful about his "standard seam" always being up to the standard. He feared that most people would have to do without their "standard seam" of coal.

He would point out in conclusion that the time mentioned by Mr. Lishman for distillation, namely, 60 to 90 minutes, indicated that he used an unusually low temperature in his retort, and, that the slow rate at which the gas passed over would tend to increase the effects in the cooling-pipes and purifiers due to variations of external temperature. The time which was aimed at in his firm's laboratory varied from 45 to 50 minutes.

Mr. James Stewart (Editor of the *Gas World*, London), wrote that if Mr. Lishman had made a cursory enquiry into the litera-

ture of gas-making he would not have introduced his paper with the statement that "there is an almost total absence in scientific journals of papers on the testing of gas-coal."* The *Transactions* of the different associations of gas-managers and the volumes of the journals specially devoted to gas-matters would have furnished him with numerous papers on the subject, to say nothing of the special treatises on gas-manufacture, from that of Clegg (published in 1840) onward. Then, after revealing his lack of acquaintance with what has been written on the subject of which he treats, Mr. Lishman asserts that "although coal-testing plants are attached to most gasworks now, they are usually of but limited use to the engineer, who still has to rely mainly on his working-scale results." It would be interesting to know what, if any, justification Mr. Lishman has for this statement. Of course, in a literal sense, the use of every separate apparatus is limited to the purpose which it subserves, and the ultimate and principal criterion of the value of a coal is found in its working results.

The object of the paper was to describe the apparatus in use at Lambton, to point out the difficulties which commonly beset the novice in coal-testing, and to explain the means ultimately employed by the author to remove those difficulties and to remedy the irregular results which had hitherto been obtained. The apparatus is of the usual type, for the distillation of 0·001 ton. Mr. Lishman is well advised in heating his retort by gas, rather than by a coal or coke fire, as it is vastly more convenient of manipulation and more under control; and with a regulated gas-supply and occasional experiments with a Siemens pyrometer, the carbonizing temperature may be maintained as desired, within very narrow limits.

The illustration† shows a scrubber with a water-supply, but, from the paper itself, it is questionable whether it is employed. In fact, with an apparatus on so small a scale it is practically impossible (except with very great loss of illuminants) to wash the gas with thoroughness, or even to remove all condensable matter from it; and consequently Mr. Lishman has to confess that, to obtain steadily concordant results, he finds heavy condensation necessary. Without some scrubbing of the gas on

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 567.

† *Ibid.*, page 574, Plate XXVIII.

wetted surfaces, it is impossible to get the minute vesicles of liquid hydrocarbons, which are carried forward mechanically by the gas, to coalesce and fall out of it. Thus, while the temperature may be brought down to a fairly low degree, the gas, containing these traces of liquid hydrocarbons, which by the rougher treatment of the gas-works are removed, will possess a high and fallacious illuminating power. And this, he (the Editor) imagined, will help to explain how colliery-analysts obtain the high results that are never borne out in practice.

An interesting part of the paper is that in which the author shows the application of a standard coal as a criterion in testing others. The method is as follows:—Having at command a coal which can be relied upon to remain fairly constant in quality, its sperm-value under certain conditions being well established, he makes a test of this coal along with every other coal being tested; and as the sperm-value shown for the standard coal, under existing conditions, compares with that hitherto determined, so is the value obtained for the new coal corrected, up or down. The idea is not, of course, entirely original. Every expert in coal-testing has discovered the use of a coal of fairly uniform and known quality for checking the reliable working of his apparatus before submitting to it some entirely new material. The systematic application of the idea, in the way recommended by Mr. Lishman, has not, however, been advocated before; and this proposal is distinctly to his credit.

There will probably always be differences of opinion and practice among gas-engineers in regard to coal-testing. The fact is, two different objects have to be served by a coal-testing plant. It is required, (1) to ascertain the comparative values to the gas-maker of different coals; and Mr. Lishman recognizes, with more justice and candour than some experimentalists have shown, that the true interest of both buyer and seller of gas-coals is served by aiming at results which approximate to what may be attained on the large scale in a well-conducted and properly equipped gas-works. The non-recognition of this principle by sellers of coal, or their analysts, has led, in the past, to much heartburning on the part of gas-managers; who, having bought on the strength of some hopeful analysis, have been justly indignant when corresponding results could not be obtained in practice.

Then, (2) the object of a coal-testing plant in a gas-works is to check both the quality of the coals periodically received, and the efficiency of the carbonizing plant and its supervision. For this latter purpose, the isolation of one or more of the ordinary working-retorts (providing, of course, the necessary separate condensing and purifying plant) is sometimes practised. And this method has its advantages, especially as it approximates closely to working-scale practice. On the other hand, the retort with its heating arrangements is not entirely under the control of the experimentalists; and the plant, as a whole, does not afford the same facilities as a smaller and self-contained one does for experimenting on improved methods of working. And in addition to furnishing a summary of actual working results, the coal-test should serve, at times, as an example of, and as a guide to, better working.

Mr. W. Doig Gibb (Newcastle-upon-Tyne) wrote that Mr. Lishman's paper dealt with a subject which was of equal interest to mining- and to gas-engineers, but the two branches of the profession would probably be inclined to judge the subject-matter of the paper from distinct sides, although in reality their interests were identical, in that it was of equal importance to both that they should be able quickly, and with a fair amount of accuracy, to determine the relative value of coals raised and used for gas-making purposes.

The literature of gas-making did not include many reliable and accurate papers on the testing of coals, and, partly in consequence of that deficiency, the methods employed in testing coal at various gas-works were at present not uniform, but depended almost entirely upon the individual ideas of those in charge. Further, in comparatively few gas-works was a coal-testing plant used at all, and an apparatus could be very usefully introduced into many gas-works where at present they relied solely upon the appearance of the coal. In such works, they were apt to blame the raw material if good and uniform results were not obtained, and did not take into consideration that there was a considerable element of doubt introduced, in that the carbonization of the different samples might not have been carried on under exactly similar conditions. While the use of a testing-plant of the size named by Mr. Lishman was, of course, of great advantage to gas-works, it could only be regarded as one which

would, in the best circumstances, give approximate results to those attained on a working scale; but it had the great advantage that the results were got quickly and economically. It was, of course, of no great use to a gas-maker in conducting experiments with different enriching agents, etc., and, for this latter purpose—as well as for obtaining more accurate results as to the carbonization of coal in bulk—it was very desirable for larger gas-works to possess, in addition to a laboratory-plant, a complete plant on a working scale.

As regards laboratory-plant, most gas-engineers would agree with almost all Mr. Lishman's conclusions; and his practice of taking a certain seam of Lambton coal as a standard was, from his point of view, an excellent one. From a gas-engineer's point of view, the writer would prefer to assume a theoretically perfect gas-coal, giving it, say, an arbitrary value of 100, and then compare the tests of the different coals against this and give as their value a number which would bear the same proportion to 100 as their value did to the theoretically perfect coal.

He had no doubt that Mr. Lishman would be subject to criticism as regards his arrangements for condensation, etc., but in the present state of coal-testing it was impossible to do otherwise than erect condensers, etc., of a size which seemed best to the designer and when those were erected (whether large or small) to endeavour to keep the whole apparatus in a room where an uniform temperature could be maintained. The arrangement might or might not give the best possible results (although experiments would tend towards getting the best) but at all events it might be counted upon to give with considerable accuracy comparative values. This (it seemed to the writer) was all that could be done, since he was afraid that no two engineers would, at the present time, agree upon what was the theoretically perfect amount of condensation required and how this condensation was to be effected.

Dr. W. Carrick Anderson (University of Glasgow) wrote that he had been much interested in Mr. Lishman's paper. Apart from the particular topic with which it dealt, it was valuable in helping to direct attention to the need there was for systematic examination and testing of coal, generally, in respect of its suitability for different purposes. In the case of gas-coals, Mr. Lishman stated clearly the difficulties that confronted the chemist in testing them for yield and quality of gas. These were of two

kinds:—(1) Those that centre in the retort, and (2) those that are associated with the cooling and purifying apparatus. Those which he classified as being due to the difference of results found in various gas-works were of course in themselves for the most part ultimately referable to one or other or both of the above groups.

Any and every coal would split up differently, according as the heat was raised more rapidly or more slowly upon it, and in practice no two firings of a retort would be identical in their effects upon the coal even with the most careful working. In an experimental retort he was afraid that, even with electrical heating, which would be more equable and more readily controlled than firing by combustion, satisfactory results could hardly be counted on, although this was a point which seemed to him (Dr. Anderson) to be worth investigating. With the condensing part of the apparatus, as Mr. Lishman's experiments showed, the same was true, and absolute constancy of result was impracticable.

They were, therefore, driven to refer their results to a standard as Mr. Lishman had done. He would suggest, however, that this standard should not be one chosen by each experimenter for himself, but that a standard gas-coal should be selected for the whole country. Such societies as the Institution of Mining Engineers and the Society of Chemical Industry might collaborate with advantage in a work of this kind.

DISCUSSION OF MR. H. BIGG-WITHER'S "NOTES ON DETONATORS."*

Mr. F. H. Edwards (Newcastle-upon-Tyne) wrote that Mr. Bigg-Wither appeared to place the responsibility of miss-fires with nitrate-of-ammonium explosives on the detonator, whereas it was a wellknown fact that explosives of the nitrate-of-ammonium class were difficult to detonate at any time, and more especially so if the explosive happened to absorb moisture, which it was certain to do if kept for any time in a store or magazine. No matter what high explosive is used, consumers could not be too careful in selecting the best quality of detonators, as this was a very important factor in blasting operations, whether in the mine or in the open.

Mr. A. C. Kayll (Gosforth) wrote that Mr. Bigg-Wither's

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 442.

practical and illustrative notes on detonators opened up an interesting and important discussion on the causes of miss-fires and incomplete detonation of explosives. It could readily be assumed that detonators would absorb moisture and be rendered useless, when packed in damp sawdust or even when the detonator was not entirely freed from sawdust before attaching it to the fuse or electric cable. In such instances, the onus of a miss-fire could, with justice, be put upon the detonator, as no sound would be heard, a clear proof that the detonator had not exploded. Miss-fires may, however, occur owing to the detonator becoming detached from the charge, when placed in position in the shot-hole or during the process of stemming, and then the detonator or the explosive would unjustly be blamed, as there are no means of ascertaining the true facts under actual mining conditions.

During the extensive series of experiments conducted by the Explosives Committee of the North of England Institute of Mining and Mechanical Engineers there were many instances of incomplete detonation of the charge caused by faulty explosives; miss-fires arising from the electric cable becoming short-circuited, when running the cannon into position;* and only two instances occurred from the detonator being defective. These detonators were subsequently tried with other electric exploders, with non-effective results. Damp sawdust could not be assigned as a reason in these instances, as the detonators were of the enclosed type with attached wires.

The question, therefore, arose: Are all detonators regular in their action when fired? The experiments of the Explosives Committee showed that many detonators caused an ignition of an explosive mixture of gas and air, but some did not. He thought that Mr. Bigg-Wither's experiments with leaden blocks might do much to elucidate this question.

Mr. Harold Bonser (Leeds) wrote that the experiments which had been carried out and illustrated by Mr. Bigg-Wither very clearly demonstrated the ill-effects created by even the slightest trace of moisture on the fulminate of the detonator, greatly reducing its force and impairing its efficiency in blasting operations by causing partial detonation of the explosive. To this cause could be attributed many miss-fires, partial detonations, and ignitions of the charge of explosive without detonation,

* *Report of the Proceedings of the Flameless Explosives Committee*, page 102.

too much attention, therefore, could not be paid to this subject, as so many of the modern safety-explosives depended on complete detonation for their safety. Electric detonator-fuses had of late been much improved in quality, and compared favourably with the old-time methods of firing shots by means of a length of time-fuse, as regards cost and expense. The adoption of electricity for the important mining operation of shot-firing, not only in fiery and dusty mines, but in all other seams where blasting was a necessity, had reduced many of the chances of miss-fire. In the process of manufacture of electric fuses, the detonator is hermetically sealed on to the terminals of the wires, and this effectively excludes all moisture from the fulminate. He hoped that this paper might meet the eye of members who still pursued the ancient methods of shot-firing, and that it would induce them to give a trial to modern systems. Not only was moisture excluded in electric fuses, but, by their use, safety was assured to the workman who had to proceed to the place after a shot had been fired, and greater comfort to every person in the mine from the entire absence of fuse-smoke.

Mr. H. Bigg-Wither (Wigan) wrote that his "Notes on Detonators" had reference to detonators only, as an hitherto unsuspected cause of missed shots, and presupposed that the explosive itself, as well as the electric attachments to the detonator, were in proper working order, that the detonator did actually explode within the charge, and that, although the sound of the explosion was clearly heard, nevertheless, the charge was not detonated; the cause of the failure being that the detonator itself had become ineffective through absorbing damp, and, therefore, it did not set up a true detonating wave, which was essential in order to explode high explosives efficiently. Mr. Bonser very rightly pointed out that, in the absence of true detonation, the charge of explosive failed to perform its work, or even that the charge might be ignited and burn in the shot-hole. In this connection he had been making further experiments with detonators, fired on leaden plates, with a view to observing the relative body of flame given off by a good detonator (A, Fig. 5*) and a bad one (E, Fig. 6†). With the tester (Fig. 4‡) placed sideways, but not screened, a good detonator showed a bright

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 445.

† *Ibid.*, page 447. ‡ *Ibid.*, page 443.

flash extending about ½ inch beyond the edges of the tester, accompanied by sparks, which, doubtless, were incandescent particles of the copper tube. The flame was not solid, and in some parts was of a bluish tinge. A bad detonator, on the other hand, produced a solid body of bright white flame extending at least 6 inches on either side of the edges of the tester. These experiments were repeated with the tester screened, 4 inches on either side. A good detonator only showed sparks; whereas, bad ones showed the same bright flame, extending at least 2 inches beyond the screen.

DISCUSSION OF MR. W. E. GARFORTH'S PAPER ON AN "EXPERIMENTAL GALLERY FOR TESTING LIFE-SAVING APPARATUS."*

Mr. W. H. Pickering (H.M. Inspector of Mines, Doncaster) wrote that in cases of colliery-explosions and fires, there was never a lack of volunteers, brave to recklessness, and ready to face any danger to save life, but a corps of trained men equipped with proper apparatus would have been invaluable in many cases. In his opinion, stations should be established in every mining district, where men could be trained in rescue-work and where all necessary appliances could be stored ready for use; where also explosives and safety-lamps could be tested. Such stations should not be initiated and maintained by private enterprise, but should be supported by a small annual subscription from every colliery-owner, and the management of the stations might be entrusted to a representative committee, of a composition similar to the Boards for Examinations.

Mr. H. W. Halbaum (Gateshead) wrote that he was not anxious to throw cold water on any scheme the object of which was the saving of human life, and, speaking in the abstract, it was hardly necessary to say that he was in full sympathy with Mr. Garforth's work. He thought, however, that Mr. Garforth's method attempted to hustle them on to a stage more advanced than they were at present entitled to approach. Possibly the apparatus described by Mr. Garforth might be found useful when sealing-off a gob or other mine fire, especially when putting in the

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 169.

last stopping. But it could hardly be of any real service to a party exploring after an explosion with the object of rescue. The following reasons for this opinion might be stated in order:—

(1) Judging from Mr. Garforth's own description, the apparatus appeared to be faulty, whatever degree of excellence it might or might not attain in the future.

(2) The difficulty of obtaining pure oxygen, according to Dr. Haldane, appeared to be considerable; and if the impure oxygen, ordinarily obtainable, were employed, the use of the helmet, independently of the state of the external atmosphere in the mine, might easily bring about the very disaster that it was designed to avoid, namely, the suffocation of the wearer.

(3) While scarcely lessening the recognized danger of inhaling the irrespirable gases contained in the after-damp, the use of the apparatus accentuated and magnified the (at least equal) danger of accident due to the comparative inability of the wearer clearly to perceive his surroundings when creeping over the falls, and past the "side-wavers," and under the loosely overhanging rocks left by the passage of the blast.

(4) The benefit of the helmet was more apparent than real, as it deprived the wearer of exactly as much advantage as it gave. It might enable a man to penetrate farther into a deadly atmosphere, but, on the other hand, the man, being then farther removed from the fresh air, was put into so much greater peril when distress appeared; and, according to Mr. Garforth's account, distressing symptoms were liable to manifest themselves at any moment. Thus it clearly appeared that the measure of the helmeted explorer's penetration into the foul atmosphere was also the direct measure of his peril; and those two entities (the penetration and the peril) would remain in constant ratio, until an absolutely perfect apparatus was invented and adopted. As yet, however, there were no signs of such a perfect apparatus being put on the market.

(5) Such an apparatus as that described by Mr. Garforth, or even a perfect apparatus of the kind, would appear to be, except in the very rarest of rare circumstances, a wholly superfluous and unnecessary encumbrance in rescue-work. For, supposing that the appliance enabled the explorer to penetrate with safety to himself into the most deadly atmospheres, it would certainly never enable him to find living men in such atmospheres, and

hence he could perform no rescue in the true sense of the word. It might be replied that the apparatus would allow the explorer to fix the ventilating-pipes more quickly; but ventilating-tubes should not be fixed too quickly, or further accidents might ensue. Large volumes of gas should be removed cautiously and slowly, and be diluted with still larger volumes of air, and the pipes could be extended quickly enough for this purpose by adhering to ordinary methods.

(6) If such an apparatus was to be of real service, it was the entombed person at the face who required it. It was he who, in order to escape to the shaft, must of necessity go through the noxious atmosphere. But, in that case, he must be in possession of it before the explosion occurred. And if that very obvious view were admitted, it was the logical inference that the apparatus should become an essential part of the daily outfit of every individual workman. And did anyone seriously imagine that the average workman would continually keep his apparatus in perfect working order, in view of a contingency so remote as a future explosion?

(7) If, however, they reverted to the practical possibilities of the case, and said that the apparatus was for the use of the rescue-partly only, it was difficult to see what real want it supplied. The apparatus obscured their vision, impeded their movements, and increased their peril by temporarily concealing the state of the atmosphere. But, apart from the merits or demerits of the appliance, he contended that comparatively safe rescue-work could be effected without it. Rescue-work was not always conducted as safely as it might be: there was generally a little recklessness or impetuosity, which under the circumstances was excusable, but it was nevertheless a real element of danger. Imagine a string of rescuers traversing a passage of the exploded mine: the first man got into the after-damp and fell down; the second man ran to his aid, and was likewise stricken down by the deleterious gases, and in such a case possibly both men perished. If so, however, they perished through sheer recklessness—not solely their own, but that of the entire party. Such incidents, as a general rule, were not the necessary accompaniments of judicious exploring. He would suggest that many of those lamentable accidents might have been averted, by merely adopting the simple but time-worn and time-tried methods of the seaman and the mountaineer.

A few years ago, at a large colliery in the county of Durham, a deputy for some reason or other ventured into a foul place, and was overpowered by the gas; a fellow-workman went to his assistance and shared a like fate; yet another man went to the rescue and he, likewise, was stricken down; and all three men lost their lives. Now, had that deputy gone in with one end of a sufficient length of rope attached to his waist, and left a man outside in charge of the other end, he might, on falling, have been hauled out with little difficulty, absolutely without risk to his rescuer, and, the delay being reduced to a minimum, he himself might have been easily revived by the inducing of artificial respiration. In the majority of cases where the leading man of an exploring-party was knocked down, approximately, if not precisely, similar conditions prevailed; and in every exploring expedition through an exploded mine, the leading man, or the first couple of men, should be attached to their followers by a light but sufficiently strong rope, and at least two of the party behind should be expert at the process of inducing artificial respiration. By such means, exploring might be made comparatively safe, and in his opinion, the use of any helmet or other similar apparatus would tend to increased danger rather than increased safety. When the irrespirable atmosphere was found, it was folly to attempt to penetrate it, whether helmeted or otherwise. Such attempts to invade the undoubted atmosphere of death might be heroic, or they might be foolhardy, but they could scarcely have any tangible useful result in the way of rescue-work.

He (Mr. Halbaum) would be glad to see ambulance-instruction more widespread before adopting Mr. Garforth's heroic scheme. Falls of stone were more numerous than explosions of gas; the former class of accident was always with them, and rescue-parties after the latter class of accident needed for their own safety and efficiency little more than a capable and cautious leader, a good rope, a thorough knowledge of the Sylvester method of inducing artificial respiration, and perhaps a stimulating drink. Where Mr. Garforth's helmeted explorer was called on once, the expert ambulance-man might be called on fifty times. They might, moreover, remember the axiom that when common-sense measures fail, heroic measures seldom succeed. It was much to be feared that, whatever the case might be elsewhere, ambulance propaganda was far too much neglected in the mining

villages of the North of England; and until such neglect had been effectively remedied, it would be premature to adopt in that locality any scheme such as that proposed by Mr. Garforth. Moreover, the inevitable effect of bestowing undue attention on fascinating but impracticable systems of that kind was naturally to induce one to relax one's efforts in extending those well-proved systems, which might indeed be less showy, but which, on the other hand, were infinitely more practicable, reliable and beneficent.

The PRESIDENT (Sir Lindsay Wood, Bart.) suggested that Mr. Garforth referred not so much to the erection of depôts for the storing of life-saving apparatus, as to the desirability of erecting experimental galleries in which such apparatus could be tested.

Mr. T. E. FORSTER (Newcastle-upon-Tyne) referred to an accident at Killingworth colliery, in which the difficulty was not to rescue the men who were working in the mine at the time, but to save those who went down wearing the Fleuss apparatus.

CAPTAIN J. H. THOMSON (H.M. Chief Inspector of Explosives, Whitehall) wrote that the establishment of an experimental gallery was, in his opinion, a very important step towards the working out of a thoroughly satisfactory apparatus which would enable men to enter places where the atmosphere was irrespirable. Mr. Garforth's paper did not give a detailed description of the apparatus used in the experiments, but he gathered that it was designed to absorb the expired carbonic acid, and to supply the deficiency of oxygen. He did not think that this was the best method of attacking the problem, and, as a matter of fact, it appeared that men wearing this apparatus could not perform hard work for any length of time. The apparatus should be, he thought, of so simple a character that it would be unlikely to get out of order, even if left unused for a considerable length of time. For this reason, indiarubber pipes and any fittings which were liable to deteriorate on keeping, should be avoided. He thought that the simplest way would be, as Dr. Nicholson and Dr. Markham had suggested, to supply air from steel cylinders and to exhale into the atmosphere. The average adult exhaled about 330 cubic feet per 24 hours, but a man when doing hard work might exhale as much as 850 cubic feet, or about 35 cubic feet

per hour. If he were to carry on his back, two steel cylinders, 4 inches in diameter and 2 feet long, these cylinders would hold, at a pressure of 100 atmospheres, about 25 cubic feet of air, and would weigh, when empty, about 12 pounds each. They would hold, therefore, sufficient air to enable a man to perform hard work for nearly ¾ hour, and the supply would probably last longer than this, as the man would not be exerting himself the whole time. The cylinders might be fitted with a main valve, a reducing valve, and a regulating cock, by which latter the man could govern the supply of air at will. He also suggested that there should be a short length of helical-steel piping, passing over the man's shoulder and fitted with a wooden mouthpiece, which could be held in the mouth by means of the teeth. Air could then be exhaled through the lips, and the nostrils could be closed with a clip or, better still, with soft wax. Of course, the air which was compressed would be previously purified, and a little excess of oxygen might be added. Care should also be taken to ascertain that there was no oily or other oxidizable material in the cylinder before compression. He imagined that an apparatus of this description might be kept at a mine or elsewhere for several years, and still be ready for use at any moment. He was recently asked to consider the possibility of a man carrying an apparatus by means of which the air that he breathed could be freed from carbonic oxide gas, and he was impressed by the very considerable difficulties attending any such attempt at purifying air as it was breathed.

DISCUSSION OF SIR HOWARD GRUBB'S AND MR. HENRY DAVIS' PAPER ON "THE GRUBB SIGHT FOR SURVEYING-INSTRUMENTS."*

Mr. H. Jepson (Durham) said that the purpose of the instrument seemed to provide a permanent adjustment for parallax. The authors did not suggest that it should replace the telescope or the theodolite, and he understood that it was only useful as a substitute for the old-fashioned sight fitted with horse-hairs.

Prof. Henry Stroud (Durham College of Science) wrote that he agreed with the authors that it was impossible to focus simultaneously two or more objects at different planes. The Grubb

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 118.

sight appeared to be an important improvement, as it made the process of sighting at once accurate and simple. It should be, he thought, of especial service as an attachment to the miners' dial.

Prof. HENRY LOUIS (Durham College of Science) wrote that he had had an opportunity of examining the Grubb sight, and found that it gave fairly sharp definitions under the conditions of illumination prevailing underground, but was less satisfactory for surface-work. He found it very difficult to bring the image of the cross sharply enough upon a flagstaff standing up against the sky-line. He also noticed that the arms of the cross were rather too broad for accurate work in the instrument which he had examined; in this, he found that the width of the cross at the eye subtended an angle about equivalent to a chord of $\frac{1}{1000}$ so that an error equal to the thickness of a ranging-rod could occur in a sight less than 130 feet in length. He would suggest that more accurate sighting could be done if the cross had a fine dark line along the centre of the luminous arms, or if these cross-arms did not quite meet in the centre and each terminated in a point.

He rather objected to the arrangement of the sights as adapted to the ordinary dial, because it was necessary, as now arranged, to turn the sights over on the trunnions between each fore-sight and back-sight; and there was always some risk of displacing the dial by thus handling it between two consecutive observations at the same station. It would probably be better if the sight were duplex, so that either end could be used as a fore- or a back-sight, as the case might require.

Sir Howard Grubb seemed to have overlooked the fact that in using his method of subtense measurements in plane-table work an error was introduced that might easily become serious; his instrument read off on the level-staff an intercept proportional to the hypothenuse of the vertical triangle of which the staff formed the perpendicular, the measurement really required being the base and not the hypothenuse. The distance read off would accordingly require correction by calculation, unless the ingenious appliance of Ljungström were used, as it is in some of the best Swedish plane-tables. In the Ljungström device, the alidade carries a telescope by means of which the subtense reading for distance is obtained. The alidade also carries the scale for

plotting, but this scale is engraved on a strip of metal hinged to the fiducial edge; a pricker travels along the edge, the position of which is set off on the scale according to the subtense reading. By a simple mechanical arrangement, the scale is so connected with the telescope as to be parallel to the fiducial edge when the telescope is horizontal, and to be inclined to it in proportion as the telescope is inclined upwards or downwards; so that, while the length of the hypothenuse is set off on the scale, the distance traversed by the pricker along the fiducial edge of the alidade always gives the correct length corresponding with base, *i.e.*, to the true horizontal distance. Such a device for automatically correcting the error of the subtense reading could easily be applied to the Grubb sight.

On cursory examination, it would seem that one of the most promising applications of the principle of the Grubb sight should be to the proposed modification of the prismatic compass, and he (Prof. H. Louis) hoped that this proposal would soon be worked out in a practical form.

Mr. Henry Davis (Derby) wrote that perhaps too much modesty was shewn by the inventor as to the capabilities and accuracy of the new sight. In his (Mr. Davis') opinion it would displace the telescope for colliery-surveys, both for underground and surface-work; and readings to 1 minute of arc could be made with a finely-marked sight, a degree of accuracy which was difficult to plot. A pocket monocular field-glass rendered the process easy and accurate. Doubtless, the theodolite and level would still be employed for extensive surface-surveys, but for underground work and general surface-surveys these instruments would be displaced by the Grubb sight. Referring to Prof. Henry Louis' statement that he had found a difficulty in observing the cross upon a flag-staff standing up against the sky-line: this could be overcome, in such positions, by artificially illuminating the sight, as a small electric lamp, candle, or even a match, would throw a brilliant cross upon the flagstaff. The arms of the cross could be made as fine as desired, the lines of the cross need not meet in the centre, and any other device to suit the surveyor or the conditions could be provided. There would be no difficulty in providing a duplex sight, in place of a single sight turning on trunnions, but the latter form was convenient, and no unusual care need be observed in reversing its position.

The paper, under consideration, had dealt only with the application of the Grubb sight to underground surveying; but it had several and important spheres of usefulness, in addition to its original application for sighting ordnance. Many small surveying instruments are now being fitted with the Grubb sight, such as clinometers, levels, prismatic compasses, pocket-sextants, optical squares, etc.; and, in fact, the Grubb sight may with advantage be applied to all instruments, by which levels and angles were previously measured by the eye-teasing processes of dividing the pupil and in endeavouring to focus two or more objects simultaneously, a further benefit being experienced therein that the observer need not keep his eye fixed, but may take his sight in the easiest position.

Sir HOWARD GRUBB (Dublin) wrote (with reference to Prof. H. Louis' remark, that he had a difficulty in bringing the cross upon a flagstaff standing up against the sky-line) that the sight to which Prof. Louis refers was probably one made specially for mining work, in which, as a rule, the film of sulphide of lead was deposited very thinly; as the cross was always abundantly brilliant when illuminated even by a very poor artificial light; but for overground work this could be modified and the cross made as brilliant as desired. For overground work, however, he would recommend that one or two faintly-tinted glasses be supplied, which could be placed, if desired, in front of the sight, thus reducing the brilliancy of the object aimed at, and making the cross appear more brilliant by contrast. It should be remembered that the visibility of the cross as seen projected upon an object, depended not only upon the relative brilliancy of the cross and the object on which it was projected, but also upon the intrinsic brilliancy of the object itself; because, if the object aimed at was of a very brilliant character, as in the case cited by Prof. Louis, the pupil of the eye involuntarily contracted, and consequently the cross appeared less brilliant, not only by contrast with the background, but from the fact that the pupil of the eye itself was reduced in aperture. It was only in cases where the background was brilliant that there was a difficulty in seeing the cross, and there was no objection to reducing the brilliancy of that background by the introduction of neutral-tinted glass.

He (Sir Howard Grubb) would not touch upon the matter of

the breadth of the arms of the cross, as Mr. Davis had replied to this point, except to state that one of the advantages claimed for this sight was that the ghost-image could be made of shapes and forms which would not be possible if it were a material object: that is to say, the lines may be broken lines, or dotted lines, or rings hanging apparently in space, forms which it would be hardly possible to produce, except with a virtual image. Personally, he favoured the cross with a blank centre, which Prof. Louis had been kind enough to suggest, and which he had been using for some time with gun-sights.

With regard to the suggestion that an error was introduced in the measurements obtained by the plane-table, by reason of the instrument reading off "an intercept proportional to the hypothenuse of the vertical triangle of which the staff forms the perpendicular, the measurement really required being the base and not the hypothenuse," this would be perfectly true and correct for many of the instruments which had been used for subtense work; but when Prof. Louis had an opportunity of inspecting one of his (Sir Howard Grubb's) instruments he would see that this matter had not been overlooked. It was true that a staff, held upon an eminence would subtend a smaller angle to the observer than if placed vertically under it in the horizontal plane: (1) Because it was placed at a greater distance, as the crow flies, and (2) because the staff was not at right angles to the direction in which it was viewed. But in his graphometer, so long as the plane-table was kept level, and the zero of the scale corresponded with the horizon (as it should do) that portion of the scale which was used to calibrate that staff subtended a less angle to the optical centre of the collimating-lens for the very same reasons, namely: (1) It was at a greater distance from the optical centre than the centre of the scale; and (2) it was inclined at an angle to the direction in which it was viewed, and this was in exactly the same proportion as the staff itself, consequently the result obtained was correct.

Of course, he (Sir Howard Grubb) was referring to moderate angles. If the angle at which the staff was to be viewed was very great, and the scale required to be so long that the end of it was sensibly out of focus with the collimating-lens, the above remarks would not be strictly true, and correct observations would not be possible except at the optical centre of the lens.

He (Sir Howard Grubb) would add that in making surveys with his graphometer, he did not propose that the subtense method should be used for all observations, at least where considerable accuracy was required. He would commence by chaining a line and laying down his large triangles from each end of that line, using the graphometer only as an angle-measurer; and then he would put in his secondary triangles and off-sets by the subtense method. By this means, fairly accurate surveys could be made and that very rapidly.

DISCUSSION OF MR. W. R. COOPER'S PAPER ON "ELECTRIC TRACTION ON ROADS AND MINERAL RAILWAYS."*

Mr. JOHN McLAREN (Leeds) wrote that the question of electric traction at mines was very ably dealt with in the paper, but the use of electricity as a propelling agent for vehicles on common roads was hedged about with so many practical difficulties, that he was afraid it would be a long time before electric could come into serious competition with steam and petroleum-engines. The question of moving heavy loads on common roads by mechanical means had been engaging the attention of some of the best mechanical engineers in the country, and, although no absolutely satisfactory solution had yet been obtained, most of the practical difficulties had been overcome, and the matter was now in a fairly satisfactory position. Engineers were waiting for a good storage-battery; and as soon as this was discovered, there would no doubt be an immense development of electrically-driven road-motors, both for light and heavy work.

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* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 544.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA STATION HOTEL, SHEFFIELD, NOVEMBER 8TH, 1902.

MR. H. B. NASH, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WALTER BAXTER, Colliery Manager, Silverwood Colliery, Thrybergh, Rotherham.

Mr. ALBERT VICTOR KOCHS, Colliery Engineer, Forster's Buildings, High Street, Sheffield.

Mr. ALFRED NORMAN ROUTLEDGE, Mine Surveyor, Cross Green House, Knowesthorpe, Leeds.

Mr. RICHARD SUTCLIFFE, Mining Engineer, Horbury, Wakefield.

ASSOCIATE—

Mr. WILLIAM LEEBETTER, Chargeman-deputy, 35, Cliffe View, Denaby Main, Rotherham.

The PRESIDENT delivered the following Address:—

PRESIDENTIAL ADDRESS.

By H. B. NASH.

I have to thank the members for the honour which they have conferred upon me in making me their President for the ensuing year. I sincerely trust that, during my term of office, the work of the Institute will at any rate equal that of my worthy predecessors, and assisted as I shall be by so able a Council, I feel sure that no effort will be spared either on their part or my own to attain these results.

The President's address can of necessity only deal in a general way with such subjects as are most to the front at the moment, and I purpose reviewing briefly the great changes that have taken place in our own immediate districts of South and West Yorkshire during the past forty years; and then giving expression to my views as to the future development of this valuable coal-field, feeling thankful that it is customary for the members to accept without criticism the remarks embraced in the President's address.

THE PAST.

It was my good fortune to make my first practical acquaintance with the coal-trade when it was at the height of its prosperity, in 1873. Anything black would sell, and 10,000 tons of slack, which had been used for ballasting the empty-wagon sidings, was filled and sold at about 13s. per ton at the pits with which I was then connected, and ripping-dirt was sent out of the pit to replace it.

Prior to 1865, few pits had been sunk to a depth of 900 feet, and outputs of 500 tons per day from one shaft were considered large. Egg-ended boilers ranging from 20 to 36 feet in length, and from 4½ feet to 6 feet in diameter, working at pressures varying from 40 to 50 pounds to the square inch, were in general

use. Fixed-bar screens, making only two sorts of coal (large and slack), were the only screens necessary, and coke-making was a small industry. The life of the colliery-salesman in those days, with only three classes of coal to sell, was one of comparative ease. Railway-wagons were generally of 6 tons capacity, fitted with dead buffers. Shafts were usually sunk from 9 to 10 feet in diameter, single-decked cages were universal, and winding from upcast-shafts was practically unknown. Winding-engines, with the engineman holding a pair of handles like wheelbarrow-shafts, handling every stroke of the engine, were commonly to be seen. Pumping-engines were worked on the lift-principle, with heavy columns of pipes in the shafts, and huge spears and beams at most of the pits. Cast-iron tubbing, for keeping back the water, was only coming into use at new sinkings. Ventilation, generally, was effected by large furnaces, and candles were used in all but the most fiery pits, but Davy or Clanny safety-lamps were used in those parts which were considered most dangerous. The system of working was chiefly bord-and-pillar, and dip-workings were only practicable where steam could be carried to the coal-face to actuate the pumps, often with most disastrous results to the roof. Plans were made up when the manager could find time to attend to them, with the inevitable results that inundations from old disused workings were of frequent occurrence. A royalty of 500 acres was a large take, and the majority were of much smaller area.

In 1856, the tons of coal raised in Yorkshire were 9,083,265; and 12 years later, in 1868, the output had only increased by 700,000 tons, proving that it had been practically stationary. In the latter year, the number of working collieries was 441, the number of men employed 37,000, and the mineral raised per person employed was 262 tons.

The Present.

But the prosperous times of 1872 to 1874 gave an immense impetus to the development of the coal-field, resulting in the sinking of deeper shafts of larger diameter, competent to deal with increased daily outputs. This was followed by the introduction of Lancashire boilers working at pressures of between 60 and 80 pounds per square inch, thereby enabling the speed of winding to be considerably accelerated.

Most of the shafts put down about this time were from 12 to 16 feet in diameter, lined with cast-iron tubbing through the water-bearing strata; and thence downward lined with from 9 to 14 inches of brickwork, to the pit-bottom. The shafts were usually fitted with double-decked cages, carrying two corves on each deck; and, where there was plenty of room in the shafts, wire-rope guides were used in place of the common wooden conductors. Most of the headgears, at this time, were built of pitch-pine, and some excellent specimens of joiners'-work were shewn in the fitting together and erection.

Owing to the increased demand for coke for iron-smelting, it became necessary to take the smudge out of the slack, and this had the effect of raising the pit-hills, to enable the number of railway-lines to be increased from 2 to 3 for this purpose: it being, at that time, the only way of obtaining a sufficient inclination for the screens. Since that time, jigging-screens and travelling belts have altered these arrangements. Balanced tipplers were also introduced, with the view of avoiding the large amount of breakage which took place with the house-coals. A general plan at this time was to erect screening-plant and siding-accommodation for an estimated output of 1,000 tons per day for a royalty area of 1,000 acres.

Fans, chiefly of the Guibal or Waddell types, took the place of furnaces, and they were driven direct, producing water-gauges ranging up to about 3 inches.

The Coal-mines Regulation Act, 1873, caused the use of safety-lamps to be a necessity in all but the shallow mines, and induced the great improvement which took place during this period in the different types of safety-lamps then in use. It also led to greater care and attention being paid to the cleaning and testing of the lamps before they were placed in the hands of the workmen, each morning before descending into the mine. And, as a natural consequence, there was a greatly decreased death-rate from minor explosions.

Rope-haulage was substituted for horses in the main levels and inclined planes. Compressed-air engines enabled dip-workings to be freed from water in places where it had been previously impracticable to carry steam, on account of the damage caused to the roof of the mine; and in some cases it was used in rise-headings to ventilate and keep them free from gas.

The system of working was in many cases changed from bord-and-pillar to longwall, thereby enabling larger outputs to be produced with much less pit-room, as soon as the shaft-pillars had been headed through.

Electric signalling took the place of the old-fashioned bell-wire, which over long distances often took two strong lads to pull it. There was great uncertainty (on the old system) as to whether the correct signal had been received or otherwise, and doubtless many accidents occurred through mistaken signals.

Coal-cutting by machinery was practically unknown, indeed in the Barnsley seam unnecessary; and there was little incentive to its development and application. Blasting-powder was the explosive used, either in the sinking of shafts or in the driving of drifts. All hard coal was blown down with blasting-powder, and great carelessness in its use led to many accidents. Usually it was stemmed with any material near at hand, and it was a common practice for missed-shots to be drilled out. All shot-holes, either in sinking, in drifting, or in the coal itself, were put in by hand.

The fitting-shops at the new collieries were efficiently equipped with lathes, drilling-machines and shearing-machines, and labour-saving tools were introduced as much as possible.

Grinding the smudge for coke-making was found to effect a great improvement in the density and mechanical construction of the coke; and the local demand for steel-melting and foundry-coke led to crude forms of self-acting washers being erected. At some collieries, trough-washers, depending on gravitation for their results, and at others, some of the earlier types of mechanical washers were erected, and proved efficient for small daily quantities. The beehive coke-oven, 11 feet in diameter, was the universal type, in most instances burning out of the top; but in a few cases a flue was built between the ovens, and the escaping gases were utilized in heating a limited number of boilers, thereby reducing the colliery-consumption of small coal required for the hand-fired boilers.

In the ten years which I have just reviewed, the output of coal in Yorkshire had nearly doubled itself: the figures for 1868 being 10,728,837 tons, as compared with 16,188,179 tons in 1878, an increase of no less than 5,459,342 tons, which in 1900 had still further increased to the record-output of 28,902,569 tons.

Without such comparisons it is impossible to estimate the rapid advance which mining-engineering has made in Yorkshire during the last half-century, and my main object in putting together these notes is to combat the statements so frequently made that mining-engineers are not moving with the times, and that the foreigner is far ahead of us. Further, to show that as circumstances have arisen, the mining-engineers and managers of Yorkshire collieries have adapted themselves to them, and advanced with the times as required by the altered conditions. For this purpose, it is necessary to look at things as we find them to-day, and I think that all will be prepared to admit that no mean advance has taken place during the last 20 years in the equipment and increase of daily outputs from the collieries.

During this period, many of the older pits have become exhausted, and the works closed, few sinkings have been made of less than 1,200 feet in depth, and in some cases a depth of nearly 2,400 feet has been reached. The larger outlays necessary for the sinking of the deeper shafts, at once led to greatly increased royalties to warrant such an expenditure, and areas of 2,000 acres to a pair of pits are now common. The longer time taken in winding led to shafts being increased in size so as to accommodate larger cages, and pits from 18 to 20 feet in diameter are now usually sunk, fitted with cages capable of holding four tubs on each deck and 3 and 4 decks high. The loading and unloading of these decks simultaneously by mechanical means, at both the top and bottom of shafts, has led to large daily outputs being drawn from single shafts, and 2,000 tons daily at the newer collieries is not at all an uncommon output.

Fans of much smaller diameter, thereby requiring much less costly foundations, running at high speeds with high water-gauges, have enabled immense volumes of air to be passed through the workings, thereby allowing larger numbers of men to be employed in each mine under more favourable conditions than heretofore.

The use of electricity for hauling, pumping, coal-cutting and lighting, is making rapid strides, and its adaptability for the application of mechanical power in almost any situation is such that the time cannot be far distant when it will replace 90 per cent. of the present steam-engines, at a much less cost than the present wasteful system, where the actual percentage of useful effect is very small.

Water-tube boilers working at pressures varying from 120 to 200 pounds to the square inch are being used at the collieries now being sunk, and compound engines for fan-driving, air-compressing or generating electricity are coming into general use.

Elaborate screening-plants, capable of making a dozen varieties and sizes of coal, fitted with revolving-tipplers, picking-bands and jigging-screens, to deal with large daily outputs, are an absolute necessity, and as the seams below the Barnsley seam are more generally worked, washing- and sizing-plants will become necessary.

Headgears are now nearly all made of latticed girders, and all the plant about the surface is so arranged that the risk of fire may be reduced to a minimum.

Longwall, in one form or another, is the rule, and bord-and-pillar the exceptional method of working.

Coal-cutting machines, driven either by compressed air or electricity, made to hole to depths varying from 3 to 6 feet are now working very successfully; none but the improved forms of safety-lamps are used; and shot-firing is confined to one or other of the permitted high explosives, used under conditions calculated to ensure safety in their use as far as possible.

Coke-ovens are now in use at nearly every colliery, and usually all the small coal is converted into either furnace or foundry-coke, chiefly in beehive coke-ovens of standard size and type. A few bye-product plants have been erected, but these are mostly dealing with small coal from other than the Barnsley seam.

The tendency of the railway-companies is to require the use of wagons which have a carrying capacity of not less than 10 tons, and to introduce as early as they conveniently can wagons carrying 50 tons each. Whether for anything but special traffic the use of these larger-capacity wagons will become general or not, time alone can prove.

The Future.

And now, having briefly sketched out the changes that 50 years have worked in the development of the coal-field and the equipment of the mines, let us turn our attention to the future, while I endeavour to put before you my views, as to what will have to be dealt with and the best and most economical methods (consistent with efficiency) of dealing with it.

So long as the chief coal to be dealt with was the world-renowned Barnsley seam, no special methods of working, cleaning, sizing or sorting were necessary. Therefore no incentive was present to induce the colliery-manager or mechanical engineer to leave the beaten track followed by their predecessors in the elaboration and application of expensive machinery for improving its marketable quality; but the time is now at hand when the question of the active development of the seams lying below the Barnsley seam, and possibly some of those above it, must be taken in hand, and consequently the increased cost of working owing to the following causes must be considered.

The admitted inferiority in quality of these seams to the Barnsley seam, the presence in them of thin bands of dirt, the thinness of the seams themselves, the greater depths at which the bulk of them will have to be worked, the tender nature of both coal and roof, and consequently the greatly increased percentage of shale and other impurities are facts which cannot be denied. I venture to think that those of our members who were fortunate enough to take part in the recent visit of the Institute to Rhineland and Westphalia had a splendid opportunity of judging how the foregoing natural disadvantages, as applied to their coals, and the extraordinary large percentage of small coal, had compelled German engineers to devote special attention to these details, and as they have benefited by our experience in the past, we may hope to benefit by theirs in the near future.

Now it must force itself upon the minds of every member that the initial outlay for dealing successfully with these deeper and inferior seams must necessarily be greatly in excess of that hitherto required for the successful working of the Barnsley seam. Therefore, to ensure the recoupment of this extra capital much larger royalty-areas will become an absolute necessity: say, for example, 3,000 to 4,000 acres from one pair of shafts, when an entirely new plant is being put down. I am afraid that in our present system of small freehold ownerships in the minerals, and minimum rents, will be found the most serious drawback to the successful development of these seams; but this is a matter over which we have no control.

These initial difficulties having been overcome, and the site for the shafts having been determined, the most important question is the laying out of the surface-arrangements, and, in

my opinion, too little attention is paid to this important matter. It will be more than ever necessary as coke-ovens with bye-products recovery-plants become more general; and it is worth considering whether any benefits accrue from sinking your pits alongside a main line of railway, as has been hitherto customary in this district.

In my opinion, it will be advisable to have your yard divided into two parts with the shafts between them, the screening apparatus and coke-manufacturing plant being on one side, and the workshops, winding- and fan-engines, storerooms, stables, offices, etc., on the other. These should be so arranged and laid out as to reduce the cost of surface-labour as much as possible, and by attention to little details in the handling of the timber, stores, hay, corn, iron, steel, rails, corfe-repairs, etc., a saving of 1d. per ton on all the coal produced may readily be effected. It is also essential that space should be left for extensions, when laying down the general design, so that, when necessary, extensions can be made without destroying the general plan of the surface-arrangements of the colliery.

The shafts should be sunk of such a diameter, where their depths are likely to be 2,000 feet and over, that they are capable of containing two separate sets of cages, running in each shaft at the same time with independent winding-engines. The decking arrangements, at both the top and bottom, should be performed mechanically, and all the decks should be loaded and discharged simultaneously, so that while the cages are running in the shafts, the banking and screening may be done without hindrance to the winding.

This leads me to the consideration of what may prove a most interesting feature in the future. The question as to whether, when dealing with these seams of inferior quality and containing large admixtures of foreign matter, such as shale and bits of roof-stone, it will be more economical to erect elaborate screening-arrangements with numerous picking-bands, etc., employing an army of lads to sort it by hand; or whether, although the first cost may be higher, it will not be a sounder policy to divide the coal into large and small sizes, with simple jigging-screens, cleaning the large coal on belts and carrying all the small coal direct to large washeries, where the action of the water, etc., will take out far more of the impurities than can possibly be done by hand,

and where not more than 10 men will comfortably deal with 250 to 300 tons of coal per hour, attending to the washing, sizing and loading into the settling-tanks of both coal and dirt. Personally, I think that the latter system will be found the cheaper of the two. It must also be remembered that the smudge from these seams cannot be coked successfully in either beehive or bye-product coke-ovens unless it be washed. A washing-plant becomes an absolute necessity, and it should be erected large enough in the first instance, to wash the whole of the small coal.

I think it will be admitted that where coal-cutting by machinery is necessary, electricity is the most suitable form of power; and I am also convinced that no form of mechanical energy is so easily adaptable to endless-rope haulage as electrical power. With the rapid strides which are being made daily in the safer working and handling of electricity, the time is not far distant when inclined planes will be actuated by it in preference to either steam, compressed air, or band-ropes: the motors in all cases being placed in intake airways. Where electricity is carried long distances inbye, for actuating dip-pumps, auxiliary fans, or coal-cutting machines, the danger of short-circuiting may be greatly lessened by carrying the cables along opposite sides of the roads, thereby preventing the probabilities of contact from falls of roof, etc.

Surface-equipment next demands our attention, and as steam is our motive power, the method of producing it should claim our first consideration. All boilers, whether Lancashire or of the water-tube type, will, at new collieries, be put down to work at pressures varying from 120 to 200 pounds per square inch whether fired by hand, mechanically, or by the waste-gases from coke-ovens; and high pressure necessitates the steam being used expansively.

The winding-engine of the future, of the compound type, fitted with automatic steam-brakes and steam reversing-gear, will be adopted for economy's sake. The other engines on the surface, except locomotives, will be used for generating electricity in bulk, and these engines will be of the triple-expansion condensing type, all housed under one roof. At present, engines are spread all over the colliery-yards, and more steam is lost by condensation in many cases than is actually consumed by the engines themselves. I think that all who have seen electric

motors working, and the ease with which they can be started, stopped and regulated, will admit that fans, coal-disintegrators, lathes, machine-tools, circular saws, and all classes of machinery, about a colliery, now actuated by a steam-engine, can be efficiently and economically driven by a motor of the same power, with greater cleanliness, a considerable saving of room and expensive foundations, and less noise and confusion. At any rate, the experience of those with whom I have conversed, who have adopted motors for any of the foregoing uses, was expressed in the terms that they would be very sorry to go back to the old method of steam-driving.

Then compare the heavy ranges of ugly, dangerous, wasteful steam-pipes (running all over the colliery-yard, requiring in winter-time an immense amount of attention to keep them in working-order and to prevent joints from being broken, and heavy condensation) with a bare copper wire carried overhead on light standards, or a cable buried in the ground, being all that is necessary in the case of electricity. With proper attention and carefully-recorded testing every week for leakages, electricity can be maintained at a minimum of cost, with practically no loss of power, except the resistance, which is much less than the frictional loss due to the flow of steam in pipes.

The great advantages to be gained from the concentration of all power at one central station are secured by electricity generated in bulk and produced at a low cost per unit. The generators can be all of one size and pattern, so that duplicate parts fit any of the machines in case of accidents, and a spare armature and machine may be kept available for use at short notice in case of a breakdown of any of the generators. A further saving is effected by the decreased number of attendants required, being much less than if the plant is scattered about in different places: and the manager or engineer has much better opportunities of supervision when he can see all the men together by walking into one engine-house, than when he had to travel round the pit-yard to find them.

Another question which must occupy the serious consideration of every manager in laying out a new colliery-plant in this age of working with high-pressure steam is, will it pay to work condensing-engines? And this question can only be answered after a full examination of both sides of the question. On one hand

there is:—(1) The economy in coal and water; (2) reduction of interest on capital and depreciation of plant by the lessened cost of the smaller boiler-plant required for condensing-engines; and (3) the lessened cost of labour in the boiler-house engaged in firing, attention, carting away ashes, etc. On the other hand:—(1) The cost of power for driving the condensing-plant must be considered; (2) interest and depreciation on the cost of the plant, area occupied, etc.; (3) extra cost of stores and labour for operating same; and (4) cost of water-supply. In my opinion, there are few instances where a condensing-plant will not return ample interest on the outlay, and especially is this the case when it is applied to a central-power station, similar to the one that I have already described.

The profitable disposal of coal-smudge is a serious matter at a large colliery, and I think that its manufacture into coke is the only efficient way of accomplishing this object. But as to whether this shall be done in the old-fashioned standard 11 feet beehive coke-oven (where, although the gases may be used for boiler-firing, the bye-products are allowed to go to waste); or whether it is more economical to put up one or other of the different types of retort-ovens, with their attendant plants for the recovery of the bye-products and utilization of the waste-gases is a great question, personally, I am not sufficiently well acquainted with the cost of working bye-product ovens over a period of years to express an opinion. There seems to be such an objection on the part of those who are working retort coke-ovens to give this information, that one cannot help being sceptical as to the benefits derived from their use. It is one of the questions of the near future, so far as the development of the thinner seams are concerned, and it will require careful and serious consideration. The experience of those who have had such coke-ovens at work for 10 years would be of value to the members, and it is evident that the cost of upkeep, after the ovens have been at work for a few years, must necessarily be a serious item, both as regards the ovens and the recovery-plants, so that unless the profits are sufficiently large both to pay interest on the capital outlay and recoup the capital in a few years, the advantages of their adoption are very problematical.

There can be no doubt that the rapid advancement which has taken place during the last two years in the application of

cycle gas-engines up to 1,000 horsepower to the driving of electric generators, without the intervention of steam, may in the near future become an important factor in determining the system of coke-making. If the surplus-gases from bye-product coke-ovens could be satisfactorily used for this purpose, there would be an immense saving on the capital-outlay now necessary for boiler-plant and the value of the retort-ovens would be materially enhanced.

It must also be borne in mind, in the laying down of new sidings and screening-plants that the tendency of the railway-companies is to force forward the use, so far as possible, of wagons of larger carrying capacities than those at present employed, and to increase the height and length of the wagons with extended wheel-bases and provision should be made in designing the screens, weighing-machines and curves to meet these requirements.

The question of standardizing as far as possible the various engines or motors to be used for the different work about a large colliery is one that, I think, is worthy of more than passing comment, as every moment spent by a workman in waiting for the repairs of any machine means enhanced working costs, no matter how minute, and if ½ hour can be saved in getting any part of the machinery to work after a breakdown, by the use of duplicate parts common to several machines, they must be a source of considerable economy. I think that this is a matter which, at the present time, does not receive the consideration that the saving to be derived from it warrants. Where there are three or four hauling-engines, three or four boiler feed-pumps, and a number of separate engines for driving the fitting-shop machinery, circular saws, screens, slack-grinders, etc., very little difficulty should be experienced in standardizing the parts, and the standardizing system is applicable to a great number of other materials in general use about a colliery.

There are many other matters in connection with the interesting subject of the erection of new plants which will be erected in the next 20 years, upon which, did time permit, I should have liked to have touched; but I have no wish to weary the members. I trust that those matters with which I have been able to deal only in general terms may not have been without interest to the

members; that they may be the means of leading to the reading of papers on some of the subjects to which I have referred; and that interesting and instructive discussions may be thereby encouraged and stimulated. I have no hesitation in stating that the Midland Institute of Mining, Civil and Mechanical Engineers includes among its members as many clever practical engineers as can be found in either this or any other country, and that if conditions and opportunities are afforded to them for the exercise of their practical knowledge they are bound to come out at the top of the tree.

I trust that any members who have any machinery of general interest working at their collieries, will bring it before the notice of the members in the form of a paper, so that we may be enabled to meet together frequently for the interchange of ideas and friendly discussion thereon, and that all may thereby mutually benefit from each other's experience.

Mr. JOHN GERRARD proposed a vote of thanks to Mr. Nash for his address. He had heard it read with great pleasure, and he hoped that Mr. Nash would have a very happy and successful year of office, coupled with plenty of papers and long and interesting discussions.

Mr. H. ST. J. DURNFORD seconded the resolution, which was carried unanimously.

DISCUSSION OF MR. THOMAS MOODIE'S PAPER ON "THE WORKING OF CONTIGUOUS, OR NEARLY CONTIGUOUS, SEAMS OF COAL."*

The PRESIDENT (Mr. H. B. NASH) said that when there were two nearly contiguous seams of coal, which could not be worked together, if they worked the top seam first it made a bad roof, and if they worked the bottom seam first, they damaged the top seam so that it was not worth working, unless it was dealt with in a very careful manner in the way of packing. One point to be considered in working contiguous seams, where both are worth working and are of good quality, was the length of time that

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 283; and vol. xxiv., page 116.

should elapse between the working of the one and the working of the other, because, in taking out the bottom seam, the manner of working it would materially affect the top one, in fact the top seam might prove unworkable, if it were crushed or broken by the working of the lower seam. But if the top seam were worked first, a little in advance of the lower seam, it might be wrought economically. The angle of inclination was also a factor in determining the order of working contiguous seams.

Mr. Gerrard asked whether there were any cases in Yorkshire where the top part of a seam was worked in advance of the lower section.

The President (Mr. H. B. Nash) stated that at Woolley colliery, it was desirable to work the bottom seam first, and that the working of the other should follow at not too great a distance. The face in the bottom seam should not be driven more than 150 feet in front of the face in the top seam.

Mr. G. H. Ashwin said that for twelve years he had worked three nearly contiguous seams. The top seam (called the Two-yards) was 5½ feet thick; there was about 3 feet of strata between that and the Ryder seam, 6 feet thick; below was about 4 feet of good coal, which they did not get, except the bottom part of it; and below was the Slate coal, 3½ feet thick. These seams lay at angles varying from 12 to 17 degrees. The seams were worked on the longwall system. The bottom seam was taken out first; then the Ryder seam, 75 feet behind; and lastly the Two-yards seam, 45 feet farther behind. At a neighbouring colliery, an unsuccessful attempt was made to work the top seam first. There were three collieries in Yorkshire working three contiguous seams, one working four seams, and two or three collieries were working two seams. In every instance, the lower seam was the first one to be worked.

Mr. W. H. Pickering remembered a colliery where two seams were worked simultaneously. The bottom seam was the first one to be worked, about 36 feet in advance of the workings in the top seam.

DISCUSSION OF MR. W. E. GARFORTH'S PAPER ON "THE APPLICATION OF COAL-CUTTING MACHINES TO DEEP MINING."*

Mr. G. Blake Walker said that coal-cutting in the Florence colliery, North Staffordshire, in a seam about 1,800 feet deep and 5 or 6 feet thick was successful. The pressure was exceedingly great, when the coal was worked in the ordinary way. The timber snapped frequently, and the coal was very small when worked by hand-labour; whereas, with the rapid movement of the machine-face, much larger coal was obtained, and the timber did not break to anything like the same extent. At the adjoining Fenton colliery, two coal-cutting machines were doing efficient work at a great depth. His own experience with regard to using coal-cutting machines at great depths had been rather in the contrary direction. In the Whinmoor seam, where he was working coal-cutters, he now used only one machine, probably because it was not worth the trouble and expense of taking in another coal-cutting machine. The coal was tender at great depths, and very much more likely to break than where the weight was less.

Mr. H. St. J. Durnford stated that his experiments with coal-cutting machines in the Silkstone seam had been more or less a failure. He commenced with a machine driven by an electric motor, and holed to a depth of 4½ feet, but it never managed to hole more than 90 feet in a shift. He then tried a large wheel, to hole to a depth of 5½ feet, driven by a larger motor, making the cutting-wheel run about 60 revolutions per minute. The holing was made in hard coal, he had seen a continuous flow of flame from the rim of the cutting-wheel, eventually there was a small explosion, and the use of the machine was forthwith discontinued. He had not the slightest doubt that this explosion was caused by coal-dust (as there was no gas) ignited by the sparks produced by the great speed of the cutting-wheel. In their seam, 1,800 feet deep, the roof was not particularly good, and the floor was decidedly bad; but there was no particular reason why he should not try again. He did not think that, in a seam of coal where the getting price was 1s. 9d. per ton, there was much profit to be gained by getting coal by machinery, but

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 312.

there was undoubtedly a large gain in the percentage of round coal. The coal-cutters in the Warrenhouse seam were cutting 150 to 180 feet in a shift without difficulty.

Mr. J. Gerrard asked whether the sparks proceeded from the cutting-wheel or from the electric motor.

Mr. St. J. Durnford replied that there was a continuous stream of sparks from the rim of the cutting-wheel.

Mr. C. Snow said that he had only had experience of one machine working in a seam 1,620 feet deep, 7 feet thick, with a bound roof. When getting the coal by hand, the roof was so good that, excepting for the requirements of the Coal-mines Regulation Act, no props would have been set; there were no breaks in the roof. So soon as the machine began to work, the roof began to break, and he asked whether that was due to the more rapid advance of the working-face. Eventually the coal-cutting machine broke down, and they reverted to hand-cutting; and they had not been at work a month, before the old conditions of roof again prevailed. The machine was repaired, and on resuming work, the roof was again broken.

The further discussion was adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE HALL OF THE INSTITUTE, HAMILTON, DECEMBER 11TH, 1902.

MR. HENRY AITKEN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. HARRY D. D. BARMAN, Airdrie Ironworks, Airdrie.
Mr. RICHARD E. M. BATHGATE, 20, Charing Cross Mansions, Glasgow.
Mr. JOHN CADMAN, 90, Marchmont Crescent, Edinburgh.
Mr. DUNCAN CAMPBELL, Greenfield Foundry, Hamilton.
Mr. JOHN GRAY, Morningside Colliery, Newmains.
Mr. DAVID LIVINGSTONE, Woodmuir Colliery, West Calder.
Mr. CHARLES LATHAM, The University, Glasgow.

STUDENT—

Mr. GEORGE HUNTER, Tinto View Terrace, Coalburn.

DISCUSSION OF MR. JAMES BAIRD'S "DESCRIPTION OF UNDERGROUND HAULAGE AT MOSSBLOWN COLLIERY, AYRSHIRE."*

Mr. JAMES BAIRD wrote that, since the last meeting of the members, he had renewed the rope of No. 1 Pit haulage-level, and consequently he was now in a position to answer Mr. Mowat's question more fully as to the difficulty of putting a rope on to the horizontal Clifton wheel and preventing the rope from becoming slack and falling during the operation. He could at once state that he did not experience the difficulty mentioned by Mr. Mowat. The *modus operandi* was as follows:—The new rope, 5,400 feet long, was taken along the haulage-road, on a reel, and placed on the empty roadway about 50 feet from the central station. The

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 155; and vol. xxiv., page 115.

back-balance weights were taken off, and the old haulage-rope cut. The new rope was then spliced to the ingoing old rope, after which operation, the haulage-system was started, and while the engine pulled the new rope off the reel, the other end of the old rope was pulled by manual power in the same direction, for about 600 feet. The engine was then stopped, and the old rope cut. The operation of drawing in the old rope, 600 feet at a time, and cutting it, was repeated until all the old rope was taken off, after which a splice, 25 feet long, was made, with the ends of the new rope. During the operation of splicing the new rope, the workmen not engaged at the splicing were employed in reeling up the pieces of the old haulage-rope, which were lying in 600 feet lengths, in the middle of the empty-hutches roadway. The operations of reeling up the old rope and the splicing of the new rope were finished almost simultaneously. The times occupied in the unreeling of the new rope, and the splicing, were 60 minutes and 80 minutes respectively. The putting on of the new haulage-rope was performed without a hitch, and no difficulty was experienced from the ropes slipping down on the horizontal Clifton wheels or otherwise.

There was an erratum on page 116 of Vol. XXIV. Line 14 should read as follows:—"but as it was *not* found necessary to alter the gearing" etc.

Mr. J. M. Ronaldson (Glasgow) said that, during the discussion at the last meeting, he noticed that Mr. Baird had made an error which ought to be corrected.* Mr. Baird in some unexplained way stated that by altering the cut-off from half-stroke to quarter-stroke, the indicated horsepower was reduced from 46·55 to 36·04. Of course a certain amount of power was required to perform a certain amount of work, no matter how they applied it, but here Mr. Baird had shewn that different horsepowers did the same amount of work.

Mr. John Cuthbertson (Kilmarnock) thought it quite possible that there could be some difference in the indicated horsepower, and that the reduction might have been effected by cutting-off the steam at an earlier point in the stroke. It should be remembered that the indicated and not the actual horsepower was stated.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 116.

Mr. J. M. RONALDSON said that, if the amount of work done in both cases was the same, then there could not be such a difference as 10·51 indicated horsepower.

A hearty vote of thanks was awarded to Mr. Baird for his paper, and the discussion was closed.

DISCUSSION OF MESSRS. JOHN HOGG'S, THOMAS MOODIE'S, AND THOMAS ARNOTT'S PAPERS ON "THE WORKING OF CONTIGUOUS, OR NEARLY CONTIGUOUS, SEAMS OF COAL."*

The PRESIDENT (Mr. H. Aitken) said that it was very difficult to say how two contiguous seams of coal should be worked. In certain circumstances it was better to work the lower seam first and then follow with the higher, and in others the reverse. In determining how contiguous seams should be wrought, all that could be said was this, that a man should apply common sense and experience to the situation and act accordingly. The least and most trivial matters might mean a great difference in the cost, and also in the size of the pieces of coal worked. The varying of the strata, so usual in our coal-fields, often rendered one way of working at one point the better, while not many feet away the other method might be the better plan.

The discussion was closed, and a hearty vote of thanks was awarded to the authors for their papers.

DISCUSSION OF MR. RICHARD KIRKBY'S PAPER ON "THE DYSART, WEMYSS AND LEVEN COAL-FIELD, FIFESHIRE."†

The PRESIDENT (Mr. H. Aitken) said he noticed, in the paper and in the subsequent discussion, that reference was made to the mussel-shells which were found near a seam of coal in this coal-field. In discussing the existence of these mussel-beds, the tendency was rather in favour of alternations of salt and

* *Trans. Inst. M.E.*, 1902, vol. xxiii., pages 280, 282 and 288 ; and vol. xxiv., page 116.

† *Ibid.*, vol. xxiii., page 291 ; and vol. xxiv., page 118.

fresh water, irrespective of the difficulty of being able to account for the alternations, as if the whole geological formation were an ordinary bath. But they had to consider that these mussel-shells were more or less in contact with iron-and-coal-forming materials. They had the process of the deposition of iron occurring at the present day in many parts of the world, and always in fresh water; and deposits of iron were not now being laid down in salt water, so far as he knew. The various beds of mussel-shells, found in the Scotch coal-fields, so far as he knew, were as follows:—(1) The mussel-bed found above the seam generally known by the name of the "Millar," usually about 96 feet above the Kiltongue seam. Here, there was a considerable quantity of ferruginous matter—clay-band, a sort of black-band, and also coaly blaes. (2) There was a bed of shells in the blaes overlying the Kiltongue seam, the Splint seam of Slamannan and Redding. (3) Mussel-shells were sometimes found on the top of the Under Coxrod coal-seam and sometimes in it. (4) Another bed of mussel-shells is found a short distance above the Collinburn coal-seam, in clay-band and sometimes in black-band ironstone. (5) There was another mussel-bed not very far from the Calm limestone. The mussels in that position were found entirely in the clay-band ironstone. And (6), there was the mussel-bed (referred to by Mr. Cadell) lying above the Smithy coal-seam at Bo'ness. He (Mr. Aitken) held the opinion that all these deposits of shells, with the exception of the last-mentioned, which he had not seen, were practically found in ironstone and coaly matter. Although to-day mussel-shells of like species were found in our seas, he adhered to the opinion, he had already expressed, that when these shells were found in the Coal-measures they were formed in fresh water.

Mr. Cadell declared that "he had shown that there was originally no connexion between two different sets of seams at Bo'ness and Bathgate, and that they had apparently been formed as unconnected areas during the Carboniferous Period."* In his opinion, however, the Bo'ness and Bathgate coal-fields were formed at one time and were one coal-field, the shale and other formations under these coal-fields were alike, and further, the limestones above these coal-fields were alike, as well as the Moor Rock and the upper coal-seams.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 120.

Mr. Kirkby had communicated a very able and excellent paper, which must have cost him a great deal of labour, and he (Mr. Aitken) proposed that a very cordial and hearty vote of thanks be accorded to him.

Mr. JAMES BARROWMAN said that, in 1834, the late Dr. David Landale read a paper before the Highland Society upon this coal-field, giving detailed sections of the strata. The paper was published in Vol. X. of the *Transactions* of that Society; and the *Transactions* of the following year contained a very full paper by the same author upon the East of Fife coal-field, being the northern extension of this coal-field.

The vote of thanks was cordially approved, and the discussion was closed.

DISCUSSION OF MR. JOHN D. MILLER'S PAPER ON AN "APPARATUS FOR CONTROLLING RAILWAY-WAGONS WHILE LOADING AT COLLIERY-SCREENS."*

Mr. ROBERT CRAWFORD (Loanhead) wrote that it was stated in the paper that "the catch-bar, D, is lowered at suitable intervals by the trimmer, allowing the wagon to move forward, step by step."† If at one of these intervals, when the catch-bar, D, was lowered, and the wagon then on the move, one of the levers refused to work, and the apparatus could not be brought up to catch the wagon-axle, the result would be that the wagon would move on. With a man at the bottom, with a trig ready, this would not happen, and supposing that he did miss his trig, then he had the brake of the wagon at his command, although it was out of reach of the trimmer at that moment. He endorsed Mr. Barrowman's idea of safety, still a man with a trig and beside the brake of the wagon had the wagon more under his command than a man holding the hand-lever of the apparatus above the wagon.

Mr. T. H. MOTTRAM (Glasgow) wrote that at the last meeting some doubt was expressed as to whether or not the Miller-Yates

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 122.

† *Ibid.*, page 123.

apparatus would effect much saving in labour. Seeing that the apparatus was manipulated by a trimmer from the top instead of by a wagon-shifter on the rails, there must be a saving of labour. Indeed, Mr. Miller pointed out that in practice, at a modern colliery during the last 8 months, this amounted to the saving of one man's time. It would be interesting to know the daily quantity passed over the screen where this saving was effected.

No less than 21 lives were lost and 28 persons injured in Scotland last year on the surface-railways or tramways of mines, and a large proportion of these were persons engaged in moving wagons. From the point of view of safety, therefore, the Miller-Yates apparatus was to be commended, for its use meant less work among the wagons and consequently less risk to surface-workers.

Mr. J. M. Ronaldson (Glasgow) thought that any appliance whereby life and limb could be saved was to be commended. Mr. Mottram had pointed out that a wagon-shifter occupied a very dangerous position, and if statistics were compiled of the proportionate number of fatalities that occurred to such employees, many members of the Institute would be surprised. Any appliance, devised to lessen the dangers of wagon-shifters would assuredly have the approval of all. How often was it the case that while a shifter was pushing forward a wagon with the pinch, another wagon came quietly forward and jammed him against the vehicle which he was moving? Surely, an accident of the character that he had described could be prevented by some simple appliance which would regulate the wagons behind, and keep them completely blocked, while the wagon-shifter was attending to other vehicles in front.

The President (Mr. H. Aitken) agreed with Mr. Ronaldson as to the necessity of doing everything possible for safety. He considered that the Miller-Yates apparatus was undoubtedly a step in the right direction, and he believed that those who contended that it would not save money, were entirely in the wrong.

The discussion was closed after a hearty vote of thanks had been awarded to Mr. Miller.

DISCUSSION OF MR. ROBT. MARTIN'S PAPER ON "SINKING ON THE SEASHORE AT MUSSELBURGH."*

The PRESIDENT (Mr. H. Aitken) said that a perusal of Mr. Martin's paper made his memory go back to the year 1858, when he had to do with the sinking of a shaft which was attended with as many difficulties as Mr. Martin had encountered:—The surface was more than one half deeper than at Olive Bank, and while they had a less amount of water than that described at Musselburgh, they had on the other hand an extra depth of soft mud and running sand. Possibly they would not have been in such a bad position, had it not been for the fact that in the sinking of their previous pits they had only to sink through about 70 or 80 feet of soft mud and sand, and then they came to the till or boulder-clay—very hard and dry. In the case to which he was referring, the till was soft—a most unusual thing—and it was not only soft but it contained a quantity of water.

In his experience in sinking through such strata, which it must be understood are clay and sand mixed (where pure sand has to be sunk through, different arrangements are required):— (1) The outside shells should be of malleable iron, bolted together with a good joint of indiarubber or tarred plaiding. The best well burned bricks of equal weights should be used, and "grout" should be carefully inserted between the plates and the bricks. Plates should be placed inside, all the way round from the crib to the top, of at least one half the whole strength of the iron in the outside shell, putting bolts through these and through the brick-walls and the plate of outside shell so as to bind the whole into one rigid mass. The inside plates should be placed at intervals and not joined laterally. (2) If no big boulders are found, the core should be taken out with the water in the shaft. (3) Weights should be added, not only at the bottom, but also at intervals up the building, gradually decreasing the quantity upwards. (4) At distances of about 15 feet apart, a pipe should be placed all the way round the inside, with small holes open to the outside, so that, if the building sticks, water can be forced out to release the shell, and allow it to sink downward. (5) All material coming out of the shaft should be deposited at least

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 126.

450 feet away from it, and the engine and boilers should be placed 150 feet away from the pit. (6) A guiding-frame should be used at the top, through which the building slides; and kept in place with wire ropes and screws attached to poles or solid material at least 300 feet from the pit.

The further discussion was adjourned.

The PRESIDENT (Mr. Henry Aitken) read the following paper on "Four Old Labour-saving Ideas":—

FOUR OLD LABOUR-SAVING IDEAS.

By HENRY AITKEN.

I. *Disposal of Rubbish.*—Many years ago, at Boghead colliery, Bathgate, the amount of rubbish that had to be tipped on the hill was from 500 to 750 tons per day. All who have worked at emptying hutches, without doors, over a débris-heap, know that there are few things more difficult to manage than the emptying, on a wet day, of a hutch containing 14 cwts. of wet fire-clay.

In order to make this work easier, and therefore cheaper, as well as to prevent the breakage of hutches going over the hill, gangways were erected, with rails on which a movable tumbler was placed. Each gangway was fixed to a centre, so that it could be moved round, and thus commanded a radius of some 35 feet, each gangway being stayed by wire-ropes from pillars or from the pit-head (Fig. 1, Plate V.).

II. *Another Method of Stocking Rubbish.*—The first arrangement served the purpose very well, but as the height of the dirt-hill was limited by the height of the pit-head, frequent changes of position were required, and the area of ground covered was large. An arrangement was designed to overcome the difficulty, consisting simply of a brick-stalk or tower with openings, at intervals, up the sides of the tower, and having an archway forming an entrance into the bottom of it, through which the hutches pass to the stalk or tower, and are raised to whatever height desired, and then empty themselves.

The plan shews fixed iron-plates to direct the rubbish as it comes out, but these might be dispensed with, and a plate placed so that the cage would lift it up just before the hutch is turned over and emptied (Figs. 2, 3 and 4, Plate V.).

The advantages of this arrangement are:—(1) Great saving in the area of ground covered; (2) great saving of labour, as the hutches might be run by gravitation to the bottom of the tower or taken from the pit to the bottom of the tower by means of a rope worked by a small engine. One man, in the writer's

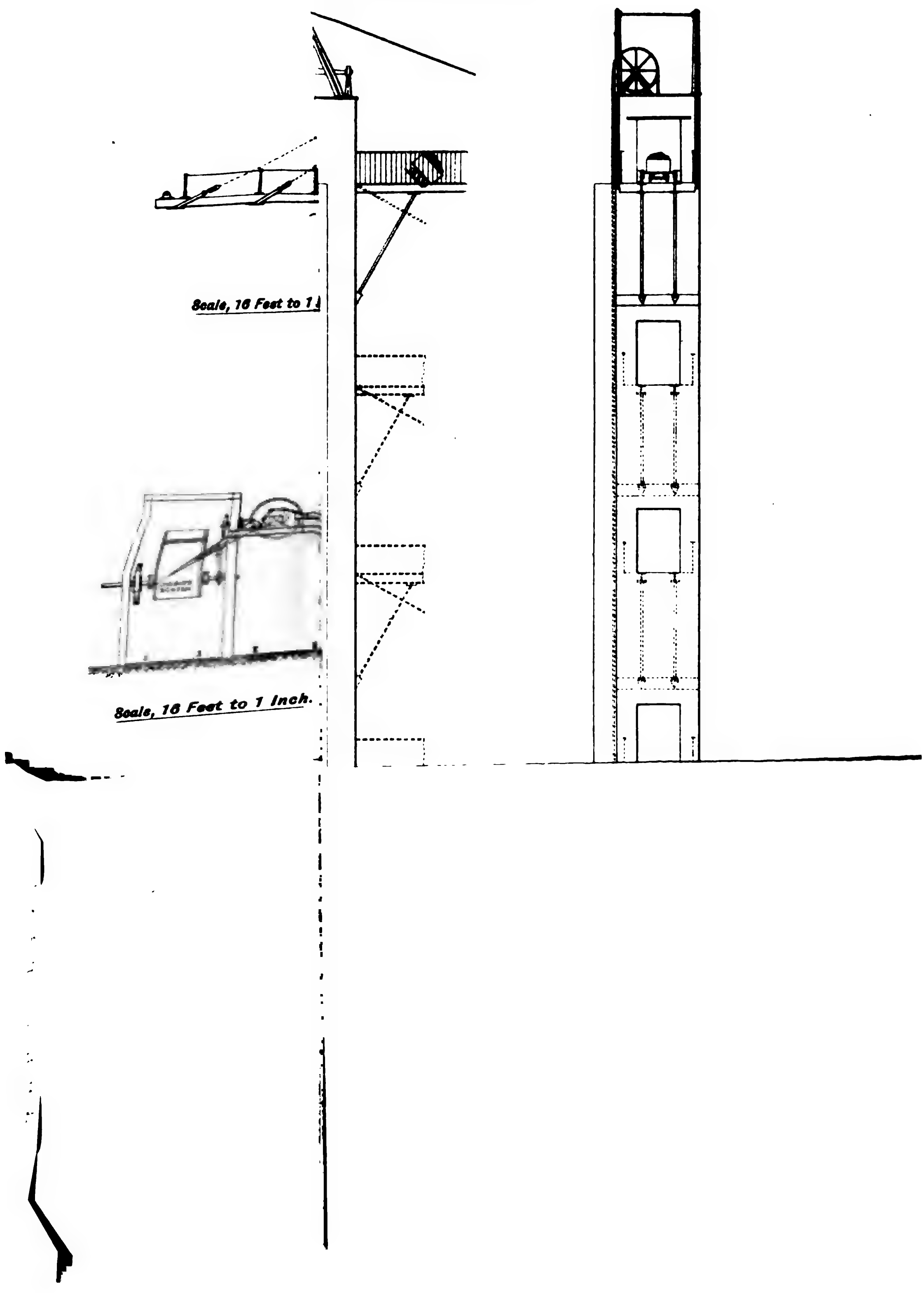
opinion, could, with this arrangement, raise and empty 150 to 200 hutches per day, and if two cages were used, two men could readily empty 300 hutches per day.

In place of the hutches being sent up, they might be emptied into an iron box, which would be raised when full and made to empty itself from the tower. This arrangement would enable very large quantities of waste-rock to be cheaply handled.

III. *Filling of Stored Coal.*—The third idea is to save labour in filling coal. It is not unusual, particularly at collieries which ship nearly their entire output, to bing coal one day and fill it the next. The writer's idea is to place an endless band in a trough, or box, on the floor of the binging-ground. Narrow planks are laid on the top of this trough, and the coal binged thereon. When the coal has to be lifted, the planks are removed one by one, as the coal is carried away to the wagons or screens: and by this arrangement one man could, with a small steam-engine, load 500 tons per day. When all the adjacent coal is removed in this way, and only one trough used, men are employed with rakes or shovels to draw or fill the coal on to the band. This arrangement would enable a large quantity of coal to be loaded at a colliery at a moment's notice, thus dispensing with a staff of labourers that are often engaged for no other purpose, or, at all events, are never employed at any other work. Instead of placing the trough above the level of the binging-ground (it being preferably so situated for hand-shovelling), the trough might be placed so that the top is level with the binging-ground, and a steam-shovel or ram could be used to place the coal on the band (Fig. 5, Plate V.).

IV. *Moving Wagons.*—The fourth idea is to save labour in moving wagons, while being filled at a screen or other place, so that the man attending to the loading on the top of the wagon does not require to go down and move the wagons forward. This saving is effected by carrying the wagons on chains or ropes, on which the wheels rest. The chains or ropes are run in a groove, and moved as desired by the attendant on the top of the wagon, by moving a handle attached to a clutch, which gets power from a revolving-shaft, driven by the engine that works the screening arrangements. The links of the chain might have a dent or curve in

"Labour-saving Ideas."



them on the top side, so as to hold the wagon to its place, where the sidings are on an incline. In place of putting the wheels carrying the chain vertically, as shown in Figs. 6 and 7 (Plate V.), they may be placed horizontally and the return-chains carried outside of the rails. If thought advisable, in place of making the chain slide along and in the iron bed below, rollers or balls might be used; over which the chain would pass and so reduce friction to a minimum. With this arrangement, should any wagons run away, they would simply pass over, and no damage would ensue.

Mr. Thomas Thomson (Hamilton) said that he could not see the advantage of erecting a brick column, which would be very expensive, for the purpose simply of raising the dirt-heap. He was afraid that they must lose something, to make up for this supposed saving.

The President (Mr. H. Aitken) said that they lost the bricks, but they saved much in labour and in ground covered.

Mr. T. Thomson asked whether the chain to which Mr. Aitken referred in his fourth idea kept the wagons stationary, or did it propel and shift them?

The President replied that the chains carried the wagons, and moved them forward as desired.

Mr. Cuthbertson said that he could not understand how the endless chain propelled the wagons. He thought that the tendency would be for the chain to make the wheels revolve instead of moving the wagon.

The President explained that a recess was formed in each link of the chain, in which the wheels of the wagon rested.

Mr. Morton said that he presumed there would be a block on which the wheels of the wagons rested; and he asked how the wagons were transferred from the rails to this chain.

The President replied that this was done on the same line of rails, by the chains carrying the wagon forward and delivering the wagon on to the rails.

The further discussion was adjourned.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, OCTOBER 6TH, 1902.

PROF. CHARLES LAPWORTH IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The Annual Report of the Council was read as follows: —

ANNUAL REPORT OF THE COUNCIL, 1901-1902.

Under the presidency of Prof. Lapworth the Institute has accomplished an interesting and useful year's work. The meetings have been well attended; and 5 General Meetings, 5 Council Meetings, and 2 meetings of the University Mining School Committee have been held.

During the year 3 members (Messrs. W. B. Scott, Arthur Wilks and E. Kidson) have died, 6 have resigned, and 4 have been struck off for non-payment of subscriptions; but as 8 members have been elected, there are now 171 on the register as against 176 in the previous year.

The receipts for the year amount to £154 9s. 4d.: the expenditure has been £181 1s. 1d., including contributions of £85 10s. 4d. to The Institution of Mining Engineers; there is a deficiency of £26 11s. 9d.; and the bank-balance has been reduced by that amount, and stands at £261 16s. 1d. This loss is owing to the heavy arrears in subscriptions, amounting to £209 11s. 6d., and the Council regret to have again to call attention to this matter. Repeated applications have been made, and a special letter has been sent by the instructions of the Council, but so many members neglect this important duty that more drastic measures will shortly be taken with the defaulters.

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1902. Cr.

	£	s.	d.		£	s.	d.
To Balance in Bank ...	288	7	10	By The Institution of Mining Engineers ...	85	10	4
,, Subscriptions received ...	149	10	10	,, Rent of Institute Room ...	20	0	0
,, Bank Interest ...	4	18	6	,, Secretary's and Reporter's Salaries ...	50	0	0
				,, Expenses of Audit ...	1	5	0
				,, Printing and Stationery ...	8	9	6
				,, Binding of *Transactions* ...	9	10	6
				,, Caretaker at the Birmingham University ...	1	0	0
				,, Postages, Telegrams, Carriage, &c. ...	5	1	9
				,, Insurance ...	0	4	0
				,, Balance in Bank ...	261	16	1
	£442	17	2		£442	17	2

BALANCE-SHEET, 1901-1902.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
To The Institution of Mining Engineers ...	50	15	10	By Subscriptions due ...	209	11	6
,, Balance ...	420	11	9	,, Balance in Bank ...	261	16	1
	£471	7	7		£471	7	7

Examined and found correct,

W. H. WHITEHOUSE.

October 6th, 1902.

This balance is exclusive of considerably more than £100 worth of property, for which no credit is taken.

The President, Prof. Charles Lapworth, delivered an Inaugural Address, mainly devoted to the subject of the education of mining engineers; and the following papers have also been read:—

"A Method of Working the Thick Coal-seam in two Sections." By Mr. W. Charlton.

"Legislation and the Ownership of Properties containing Coal." By Mr. Daniel Jones.

"The Determination of the Calorific Power of Fuel." By Mr. S. L. Thacker.

"Sparkless Electric Plant for Use in Mines and Ironworks." By Mr. J. H. Whittaker.

The President's Address gave rise to an interesting discussion, and, as an outcome, a joint committee of the Council of this Institute and of representatives of the North Staffordshire Institute of Mining and Mechanical Engineers was formed, to assist the authorities of Birmingham University to formulate the course of mining engineering. This Committee had a meeting with Profs. Charles Lapworth and R. A. S. Redmayne, and afforded assistance in regard to the scheme, now inaugurated at the University.

The members have had the use of rooms for meetings at the Birmingham University, and your thanks are due and are hereby tendered to the authorities.

The Institution of Mining Engineers, with which you are associated, continues to prosper, and now has a membership of 2,554. The Institution had charge of the Mining and Metallurgy Section of the International Engineering Congress held at Glasgow in September, 1901; and the usual London meeting was held in May last. The many papers read are printed in the *Transactions*, and are of the usual interesting and instructive character.

The Council feels strongly that individual members could and should take greater interest in the working of this Institute, and if the subscriptions were more promptly and regularly paid, the work could be more prosperous, considerable expense would be saved, and the *Transactions* could be promptly forwarded without delay.

The CHAIRMAN (Prof. Charles Lapworth), in moving the adoption of the Annual Report of the Council and Accounts, congratulated the Institute on its prosperity. He had enjoyed his

presidency, and as a member of the staff of the Birmingham University he was grateful for the kindly way in which the Council and members of the Institute had assisted them in founding the mining chair, and in drawing up the curriculum of the mining school. He was sure that in the near future, when Midland young men came in large numbers to the Birmingham University, the Institute would have a very much larger number of members than at the present day, and they would then look back with pleasure to the great assistance which they had given to the Birmingham University in promoting the education of mining engineers of the Midland counties.

Mr. W. J. HAYWARD (Treasurer) seconded the resolution.

The motion was unanimously adopted.

ELECTION OF OFFICERS FOR THE YEAR, 1902-1903.

The SCRUTINEERS reported that the following officers had been elected for the ensuing year:—

PRESIDENT: Mr. T. J. DAVIES.

VICE-PRESIDENT: Mr. ISAAC MEACHEM, Junr.

NEW MEMBERS OF COUNCIL:

Mr. W. N. ATKINSON.	Mr. J. W. NEWEY,
Mr. A. W. GRAZEBROOK.	Prof. R. A. S. REDMAYNE.

Mr. D. ROGERS.

Mr. T. J. DAVIES, in taking the presidential chair, moved a vote of thanks to Prof. Charles Lapworth for his valuable services as President during the past year. Prof. Lapworth's term of office had been signalized by the establishment of the departments of mining, metallurgy and commerce at the Birmingham University.

Mr. HENRY JOHNSON, jun., seconded the motion, and it was cordially adopted.

The PRESIDENT then delivered the following address:—

PRESIDENTIAL ADDRESS.

By T. J. DAVIES.

I thank the members for the favour and dignity which they have conferred upon me by electing me to fill the honourable office of President. I must take them into my confidence and confess that my pleasure at receiving this mark of their appreciation and goodwill is marred by a sense of incompetence and inability, on my part, to bring to this important post the experience necessary to the performance of the duties of President.

This Institute holds a prominent place in the promotion and diffusion of mining knowledge. It is the province of this Institute to take up for study and elucidation, all science, theory or invention which may affect the progress and welfare of mining-engineering. And, as in the past, you will, in the future, be initiating and conducting important discussions and investigations on the multifarious subjects which appertain to the efficiency and advancement of the mining industry. Consequently, these are some of the thoughts which induce a feeling of diffidence in my powers to fulfil the duties of President.

I do not doubt that you will afford every assistance, and extend to me your indulgence for any mistakes. I rely on your support, which I feel certain will be as generously bestowed, as the honour you have conferred upon me to-day.

In truth, the welfare and progress of this Institute do not depend on individual effort, but on the combined wisdom of the Council, Secretary and members. I place great trust in the guidance and assistance of our experienced and indefatigable Secretary who, for many years, has so diligently and successfully conducted the business of this Institute, and so materially helped to disseminate the science of civil and mining-engineering. I have also the satisfaction of looking back on a long line of distinguished past-Presidents, who have numbered among them scientists, scholars, experts and inventive pioneers in every branch of mining.

For many years, it has been our privilege to listen to the addresses of Presidents, and the lectures and discourses of other members, on almost every branch of theoretical and practical mining. The printed records of these addresses, discourses and discussions cannot fail to be of the greatest value and assistance to mining-engineers, and to all persons who are engaged in the coal-mining industry. Those in search of mining knowledge, and the sciences connected with the work of the mining-engineer, will find, in the *Transactions* of The Institution of Mining Engineers, treatises on geology, chemistry, electricity, mathematics, metallurgy, engineering, surveying and many other subjects of interest to mining-engineers.

I purpose in this address to review some of the incidents in the past history of the coal-trade, and the altered conditions attending the mining industry of the future, brought about by the progress of foreign competition in the coal, steel, iron and manufacturing trades. We are now entered upon a new century in the world's history, with many disturbing conditions, which seem to raise doubts as to whether this country is destined to maintain its foremost position in power and wealth.

Up to the commencement of last century, this country attained to position and influence principally by its agricultural wealth; and most of the people in those days were employed in the cultivation of the land. The produce from the land was then sufficient for the support and comfort of the inhabitants, numbering at that time about 8,000,000 or 9,000,000. But the population continued to increase, until it grew beyond the capacity of the land to support it, and hence arose the necessity of providing other means of existence. This want was met by the development of the mining and manufacturing trades, which provided employment for those who were not wanted to cultivate the land. The discovery at that time of extensive seams of coal, at easily accessible depths, came most opportunely for the welfare and continued progress of this nation.

We know that coal was discovered and used many centuries ago. In the sixteenth century, Dud Dudley smelted iron with coal; but it was only an experimental feat, and was not attended with commercial success; and 150 years more passed away before coal came into general use for smelting iron. I pass over this period prior to the nineteenth century, because there was no great

manufacturing demand or use for coal in the sixteenth, seventeenth, and the greater part of the eighteenth centuries.

The iron-forges erected during the latter part of the eighteenth century were built on the banks of rivers, amidst rural surroundings, and the motive power was obtained from these rivers. Wood-charcoal was used as fuel for the smelting and manipulation of the iron. Charred wood was so extensively used in the iron-furnaces of those days, that there arose a fear that the woods would fail to yield a supply of fuel for the increasing number of forges.

So little was then known, even at that late period, of the pyrology and utility of coal, that it was despondingly thought that the exhaustion of the woods would deprive us of fuel, with the consequent loss of our trade to other countries. And right up to the beginning of the nineteenth century wood-charcoal was the staple fuel of commerce.

The success of James Watt's improvements of the steam-engine, discovered to the world a method of transforming coal into mechanical power, and did more than anything else to emphasize the advantages of using coal as fuel. Its use from that time became general in all trades, and for domestic purposes, and it soon became a necessity for industry and commerce.

The great industry of coal-mining may be said to date its rise from the beginning of the nineteenth century, and is, therefore, of modern growth.

There are no records of the quantity of coal raised in the early periods of the past century; but probably about 4,000,000 to 5,000,000 tons would be the quantity annually raised at that time. The first authentic records of the output of coal in this country commence after the passing of the first Coal-mines Act in 1850; and the output had then increased to about 50,000,000 tons.

The coal-trade of this country during the past century has been a continuous record of marvellous increase and success. Side by side with the progress and development of our manufacturing industries, the coal-trade has grown to its present colossal extent; and 225,181,300 tons of coal were raised in this country in the last year of the past century.

Coal is now the only practical source of heat and power; no substitute has been discovered possessing the qualities and constituents of coal; and there are no commercially successful means

of generating heat and power except by the use of coal. I do not ignore the use of mineral-oils, or natural sources of power (such as winds, tides or rivers) which are sometimes useful to a limited extent, but are inconstant of application and of little commercial utility in this country. We have no such abundance of water-power as exists in Sweden, Germany and other European countries or in the mighty river-falls of America. No doubt more use might be made in this country of the powers of nature, but so long as coal can be obtained on advantageous conditions, these sources of power in this country will be neglected.

The art of mining and winning coal has advanced with the necessities and requirements of trade, and up to the present time has kept pace with the demand: there has not hitherto been any scarcity of workable coal. The known available coal-seams, at accessible depths, will afford a supply of coal for many years to come; but it is impossible to foretell how long this supply will last.

The time is approaching when existing collieries will be nearing exhaustion; and the coal of the future will be mined from increased depths, and its working, consequently, attended with greater difficulties. Notwithstanding that the future difficulties of deep mining will be a great obstacle to the cheapening of coal, it is becoming evident that a cheap fuel-supply will be a necessity of the future. This necessity of cheap fuel for the steel, iron and other manufacturing trades, will arise from foreign competition, which is rapidly assuming colossal proportions.

In reviewing the history of the coal-trade during the last century, I directed your attention to the unique and advantageous position of this country, namely:—That we were the first nation to develop coal-mining and its attendant manufacturing industries, and, consequently, we have maintained a leading position in the trade of the world up to the present time. You are aware that during the whole of last century we had no successful rivals to dispute our universal commercial supremacy; in the vastness and variety of our resources we were hitherto unequalled: and we commanded the markets of the world for our exports and merchandise.

It was this monopoly and commercial enterprise that enabled this country to become the richest and most successful trading nation in the world. This advantage of being the first and the

most prosperous in the markets of the world is fast coming to an end, and we are no longer supreme in the art of mining, and in manufacturing and foreign trades. We must awaken to the altered position which we now occupy with regard to foreign trade in steel, iron and other commodities.

In the future, we shall have to contend with powerful competition, as other nations have learned lessons in mining and manufacturing industries, and they have acquired our business methods and have improved upon them. Some foreign countries, like ourselves, have a larger population than can be supported by the produce of their land; and they, therefore, have to obtain from other countries the food-stuffs and necessaries which they lack in their own. These countries, also, like us, have discovered coal and other minerals: they have developed their mines and manufactures; and, from small beginnings, they have cultivated and increased their manufacturing resources.

One great nation—the United States of America—is boldly bidding for commercial supremacy; and they have, in the last few years, surpassed us in the output of coal. The production of Great Britain in 1901 was 219,046,945 tons, and the quantity raised in India, Canada, and the various colonies was about 24,000,000 tons, giving a total of 243,000,000 tons; but the quantity raised in the United States of America, was 261,000,000 tons or 18,000,000 tons more than the total produce of the British Empire.

The world's output of coal at the present time is about 700,000,000 tons, and the United States of America, therefore, stand foremost with over one-third of the world's output, and the British Empire next with less than one-third.

Germany and Belgium are rapidly increasing their output of coal, and are formidable rivals in the manufacture of steel and iron. There are other competing nations, and, further, our own colonies are annually increasing the products of their mines and manufactures. Our great dependency, the Dominion of Canada, is now embarking in coal-mining and foreign trade, and is likely to rival at no distant future the United States. The fact that some of our competitors are our colonial fellow-subjects does not mitigate the serious burden of rivalry in the competition for foreign trade.

It is, therefore, evident that the coal-trade of the future must

be conducted so as to produce a cheap supply of fuel, in order that our manufacturers may meet and overcome the competition of foreign countries and that we may maintain our leading position as a trading nation. We have now a population of over 42,000,000, and more than 70 per cent. depend on foreign trade for their means of existence. If we were beaten by other nations in the cheap production of merchandise, and their manufactures were to oust our goods from the markets of the world, our people would be deprived of the means of subsistence, and the results would be decadence in population, wealth and power.

I do not hold alarmist views in regard to our future trade and commerce, but it would be unwise to shut our eyes to the fact that other nations, and more especially the United States of America, are now engaged in determined competition against us for the trade of the world. These rivals are not to be despised, as they possess resources and advantages which are not at our command. The United States are rich in minerals and especially in coal; their population is twice as numerous as our own; they are possessed of enormous capital and manufacturing skill; they have (as I have already stated) beaten us in the extent of their coal-production; and they have now entered upon a career of exporting steel, iron and coal. (The current coal-miners' strike creates but a momentary pause in their progressive trading programme.) We are bound to admit that they have surpassed us in the economical working of coal, and proficient manufacture of steel, iron and other commodities.

Americans have given wonderful examples of admirable skill in the cheap production of manufactures, and by underselling us in the open markets of the world: this forms the new, unprecedented, and serious change of conditions, menacing our commercial existence, with which we start the new century; for we have never in our previous history had to contend with such serious competition.

I am not saying that, as a mining and trading nation, we need be appalled or despondent, but we must become alive to the fact of the coming commercial struggle for the trade of the world. We must consider and forecast the probabilities and possibilities of the new industrial situation; and whether we can equip ourselves to manufacture and export our steel, iron, machinery and other commodities of commerce at such cheap prices as will com-

mand an amount of trade sufficient for the maintenance of our existence, power and wealth.

I assume that we can trust with confidence to the skill and inventive genius of our scientists, capitalists, engineers and manufacturing experts in the steel, iron, engineering and manufacturing trades, to produce all articles of commerce at such low values as will command a market for them: and it will devolve upon mining-engineers to provide our manufacturers with a plentiful and cheap supply of fuel, in order that they may be able to produce goods for export-sale at competition-price, on sound commercial principles, giving fair wages to the miner and profit to the capitalist and mine-owner.

It would seem that, in the future, it will be necessary for this country's continued prosperity that there shall be co-operation and union of interests between the coal-industry and manufacturing trades; and there must be alliances of the industries of this nation to combat the invasion of foreign competition.

The necessity for a cheap supply of coal in face of the increasing cost and difficulties of coal-mining, is a problem which the coal-owner and mining-engineer of the future will have to solve. The increasing cost and difficulty to which I allude are due to the approaching depletion of our existing coal-fields, and the increasing depth from which the coal of the future will have to be mined. This task is set before the coal-mining industry of this country, and will most likely have to be dealt with during the lifetime of some of the present members; and it will be the work and patriotic duty of the forthcoming generation of mining-engineers to solve the difficulty of working coal from great depths, and at such cheap rates, as will enable our manufacturers to meet and overcome the competition of neighbouring nations, and particularly that of the United States of America.

These are, admittedly, disquieting and grave considerations, but I entertain no pessimistic visions of failure, and whenever the necessity for cheaper or increased quantities of coal arises, I believe that, notwithstanding all difficulties, the requirements of our manufacturers will be supplied. The continued progress of mining science built upon the knowledge which we already possess, the improvement of mechanical agencies, and the increasing skill acquired by study and experience, will enable the mining-engineer of the future to achieve triumphs which to us at the present time would seem difficult of realization.

It is somewhat of a digression, but I will now refer for a moment to Adam Smith's *Wealth of Nations*, published in the latter part of the eighteenth century, in which he explained that political economy was the science of producing from the earth the necessaries and comforts of mankind in the most economical, advantageous and beneficial manner. He shewed that superabundance of produce constitutes wealth; that all wealth comes initially from the earth, but is essentially the result of labour; and without the application of labour and the science of the agriculturist, that the earth would not produce sufficient food, necessaries and comforts for its inhabitants. Similarly with regard to minerals, they are of no value, until the forces of labour are employed to place them at the service of the community, for their necessities, comfort and wealth. Under the designation of labour, are included, not only the labour of the workman, but the many forms of mechanical labour and force, which the skill and genius of the engineer and scientist have invented. Above all and by far the most important labourers are the geologist, the capitalist, the engineer, the manager and all who have to guide, stimulate and control these human and mechanical forces. It is the work of the mining-engineer so to regulate and apply human labour and mechanical agencies that coal may be produced for all classes in the most beneficial and economical manner: and, consequently, the art of producing cheap coal or cheap manufactures is brought about by the skilful and beneficial employment of labour.

I have already stated that the output of coal in the first years of the nineteenth century was probably under 4,000,000 tons. Previous to that time, mining was in the experimental stage, practised in a simple and crude manner, and without steam-power or other mechanical aids. Coal was then worked only at the outcrop and shallow depths by quarrying, or by means of bell-shafts, and the workings extended only a few feet from the shaft.

It is a common practice in rhetoric to resort to fable to strike a contrast or depict a truth. I will, therefore, for a moment, adapt my theme to the rôle of the prophetic seer of fiction, and I will ask the members to carry their minds back to the commencement of the past century, when coal-raising was of such small proportions. I want you to picture to your imagination the

sylvan woodlands, arcadian valleys and verdure-clad district of Hamstead, near Birmingham, as it existed in all its primeval and natural beauty, prior to the last century. The rustic inhabitants of the few scattered hamlets in that neighbourhood would be aware of the new and wonderful discovery of coal-fuel, under lands about Dudley, Wednesbury, Wolverhampton, Pelsall, and other places where outcrops occur; the few acres found in these localities would appear, to them, as surprising and large deposits: and their ideas of mining operations would be confined to the knowledge and practical working of these outcropping coal-seams. They would discuss the advantages which would result from the general use of coal compared with the restricted utility of wood-charcoal. The sage of those days would be listened to, on the geology and existence of coal and its value to the commerce of the nation. The seer would predict future possibilities and tell this rural people that in that hamlet, before the century had expired, coal would be raised from beneath their feet, from a depth of nearly 2,500 feet, at the rate of 1,000 tons a day, out of one shaft; and that there would be many such wonderful productions of coal out of the earth from great depths even to the extent of 200,000,000 tons in every year.

The prophet who would make such a forecast in those days would not be believed; and it would be beyond the capacity of their understanding to credit the existence of coal at such depths, or the possibility of its being transferred to the surface in such immense quantities. The forecast would at that time seem impossible of realization by any known human agency; and, certainly, not one person in 100,000 would give credence to such an estimate of coal-production.

I have made use of this allegorical prophecy, to emphasize the marvellous progress of coal-production during the past century. We have now in our midst, the examples of Hamstead, Sandwell and the Cannock Chase collieries raising 1,000 tons per day, and in many parts of the kingdom, there are collieries where 2,000 and even 3,000 tons per day are raised to the surface from a single shaft.

A year's output of coal has now reached 228,000,000 tons: to illustrate the magnitude of this quantity I have calculated that, if it were stacked 6 feet high, it would cover 39,000 acres, or if stacked 6 feet high and 1 mile wide, it would be 61 miles long; and this is only one year's production of coal in Great Britain.

Having witnessed this marvellous development of mineral production during the past century, may we not expect still further expansion in the future. The trend of events indicates that increased quantities of fuel will be required, in proportion as population continues to multiply, and trade and manufactures increase; but what may be the increased quantity is interesting matter for conjecture.

Shall we double or treble our present output of coal during the present century, or will the total required reach 1,000,000,000 tons per annum before the century closes? I do not think that even the latter total can be characterized as beyond the limits of human science and energy.

Naturally we ask:—Are our coal-deposits sufficient to supply such an increase as I have imagined for any considerable length of time? We have been furnished with many and varied expert assurances, and geological evidences, that our coal-resources are sufficient to supply the increased wants of the United Kingdom for the next 200 years, if we are prepared to work coals from depths of 3,000 to 4,000 feet. In the address given last year by my predecessor, Prof. Lapworth—a most valuable and instructive geological discourse—he pointed to geological evidences of Coal-measures in the Midland coal-field below the present workings, or of correlative seams in the surrounding country. The report of the Royal Coal Commission in 1871, gives an estimated duration of 270 years for our coal-supply, with an increased consumption of 400,000,000 tons annually. But, as is well known to every one who has any connection with the coal-trade, there are continual discoveries of coal taking place in various parts of the kingdom, all adding to, and increasing our security in regard to fuel-resources. There is, therefore, not much cause for alarm in regard to any early exhaustion of our coal-deposits.

What to my mind is of more serious uncertainty, is the industrial problem of working the deep mines of the future:—How are the geological and natural difficulties of deep mining to be surmounted? How will the natural heat of the mine be overcome at depths of 4,000 to 6,000 feet? as the increase of heat at this extreme depth would range from 60° to 80° Fahr. higher than the surface-temperature. Then as regards ventilation, and the presence of noxious and dangerous gases: we must expect difficulty in dealing with these in the extensive roads and workings of deep mines.

At present, it would not be possible to work mines 5,000 feet deep or more; but when the necessity arises, who shall say that mining science will not have advanced, so that, by chemical and mechanical inventions, the atmosphere of deep mines can be freed from injurious gases, and the air cooled down by refrigerants to the temperature necessary for the safety and health of the workers in the mines? If this obstacle to the ventilation of deep measures can be overcome, all other difficulties of an engineering character—such as gaining access to the deep seams, raising to the surface, haulage and draining—present no insurmountable mechanical difficulties.

What then may the mine of the future be like? What will be the possible future development of deep mining, as year after year, in progressive stages, natural, geological and atmospheric difficulties are overcome in the working of deep mines? Shall I venture to pose as a seer for a moment? The mine of the future may lie from 5,000 to 10,000 feet below the surface. There is of course a limit to the depth from which minerals can be vertically raised by wire-ropes, by reason of the weight of the rope; consequently this very deep mine will have to be reached by inclined drifts or tunnels, 6 or 8 miles long. There will be two, three or four drifts or tunnels (of large dimensions) to this mine, securely cased or lined with stone or brick masonry, similar to existing railway-tunnels. Double lines of rails will be laid in the tunnels set apart for traffic, an inward or down line, and an ascending or return line. Electric locomotives will travel up and down these tunnels, drawing trains of wagons; in the inward journey with empty wagons or material for the mine, and returning to the surface with coal-laden wagons.

There will be separate intake and return air-drifts to the workings of this mine, in addition to the tunnels used by the locomotives for ingress and egress from the mine. The ventilation of this vast mine will be accomplished by copious mechanically induced and propelled air-currents, aided by scientific chemical and electric inventions by which the hydrocarbon gases given off in the mine will be rendered innocuous by reduction of temperature or liquefaction brought about by chemical agencies.

The excessive natural heat of the mine will be counteracted by the production of artificial cold and the copious air-currents.

This mine will be of vast extent, working several seams at

different levels, by many miles of road and airways. In it, 7,000 or 8,000 men will be continuously employed. It will form a subterranean town of mine-workers, who will remain underground for days together without ascending to the surface. The output of this mine will be 30,000 to 40,000 tons per day, or from 11,000,000 to 12,000,000 tons per year.

The top of this mine will present the ordinary features of a large railway-station and ironworks combined, with the difference that the product will be chiefly coal. There will be an absence of the now familiar head-gear of pit-frames, pulleys and ropes. There will be large steam-engines at the top of this mine, generating electric power for actuating the motors of the locomotives, fans, pumps and hauling-gear, and lighting throughout the many miles of tunnels, roads and workings in this vast mine: together with improved belts, screens, washing apparatus and all appliances for sizing, sorting and washing the coal.

The incidence of the coal-trade will be diverted into new channels, as a portion only of the produce of this coal-mine will be sold in a concrete form. Large proportions will be converted and sold either in gaseous form or as electric current. The mine-owner of the future will, therefore, have to erect the necessary plant of gas-producers, storage-tanks, and mains for the supply and conveyance of gas to consumers for the purposes of light, heat and power; also power-engines and dynamos for generating electricity for sale to the various surrounding corporations, industries and trades requiring light and power; and the old commercial system of small undertakings will give place to huge combinations of capital, united to the progressive skill and wisdom of our future mining-engineers.

No doubt this representation has the appearance of a mere mining romance, but I do not think that this forecast is an extravagant estimate of the capacity and triumph of engineering science when we have such a wonderful substructure of past experience and achievements, on which to build up future success.

It is reassuring to see that the uncertainties and difficulties in the path of the future commerce of this country are realized by the mining and trading communities. It becomes the duty of those engaged in mining, and of all business men, to make preparations to meet the forthcoming formidable foreign competition by adopting the aid of science. It is, therefore, most

satisfactory that the Government have recently appointed a Royal Commission to ascertain our future resources of coal. The subjects referred to this Royal Commission are of wide scope, including economy and reduction in working costs, the most important question, and at the same time, the most difficult of solution. Geologists must assist and direct our efforts to discover our hidden treasures of coal; and mining-engineers must solve the problem of economy and reduced cost of working the deep mines.

It affords great satisfaction to know that two past-Presidents of this Institute—Prof. Lapworth and Mr. Arthur Sopwith—are members of this Royal Commission; and the selection is eminently satisfactory in regard to the geological and engineering branches of the inquiry into our coal-resources.

The Government have the further duty of protecting and encouraging our coal-export trade. I regard the imposition of the tax on exported coal as a retrograde policy and detrimental to the coal-mining interests of this country: because such a tax necessarily tends to restrict both the output and the export of coal, with consequent loss to the nation: and it is to be hoped that the anomaly of taxing our own exports will soon be remedied.

Among other gratifying preparations for meeting the near commercial struggle are the establishment, by the governors of the Birmingham University, of a faculty of commerce and accounting; the appointment of Prof. Turner to the chair of metallurgy; and that of Prof. Redmayne to the chair of mining. For a long time there has been a department of geology, presided over by Prof. Lapworth, and other departments of science, useful and necessary to the career of the mine-manager and engineer. These are some of the facilities for imparting higher, technical, and advanced theoretical and practical education in the art of mining and its allied trades in this district.

There is also the valuable work of disseminating mining knowledge performed by The Institution of Mining Engineers. The association of this and kindred institutions is now more than ever a requirement of the times, as a means for the diffusion of the knowledge of improvements, inventions, and new methods in the working of coal. It would be most gratifying if those who are connected with the working or management of mines would join in greater numbers one or other of our mining institutions.

Increased membership is required to impart tone, vigour and new life to our *Transactions*, and more papers should be read and discussed by our members. There can be no lack of matter attending an industry beset with so many vicissitudes as mining. There are many incidents in the working of mines relating to ventilation, noxious gases, methods of working under various conditions of roof or floor, mechanical appliances, fires and water in the mine, all forming interesting subjects for papers. Accounts of an endeavour to surmount some difficulty, although the experiment may have been unsuccessful, are always welcome matter for discussion. The discussions arising out of the reading of papers afford opportunities of obtaining valuable opinions and experience from the older members, who are always willing to impart their knowledge and to help their juniors. These are some of the means by which we shall become prepared and equipped to engage in the mining and commercial struggle of the future.

In the future, as in the past, trouble and difficulty will be encountered in mining operations. Our predecessors have met and overcome difficulties without the advantages and mechanical agencies that we possess; and whatever problems of mining practice have to be faced, future mine-managers will have for their guidance, the record of past failures and successes.

The occupation of a mining-engineer may aptly be compared to that of a general engaged in warfare:—Geological and natural impediments, constant vicissitudes in the form of obstruction and difficulty, and dangers of many kinds, encompass the occupations and duties of mine-managers and workers, in the exploration and winning of minerals buried deep in the earth. The necessity for cheaper coal and manufactures arises, and the skill, capacity, resource and energy of our mining-engineers and mine workers will be exerted to aid our manufacturing corporations in preserving our necessary share of the markets of the world. We shall not be discouraged by temporary defeats, but, as in the past, we shall succeed in maintaining our existence, prosperity and wealth.

I now thank the members for their patient attention, while I have treated upon a subject which concerns all of us: and I trust that I have touched on points interesting and acceptable to you, and such as will help to remind us of the work which lies before us.

Prof. CHARLES LAPWORTH said that he had perfect faith in the success of Great Britain in the struggle for the commerce of the world. Even if the coal-industry of the United States was so much ahead of our own in 1901, the chances were that Canada (our own colony) would ultimately be in front of them. The quantity of available coal in Canada was enormous, and the availability of that coal with respect to the seashore was excellent. He had great pleasure in moving a vote of thanks to the President for his interesting address.

Mr. H. W. HUGHES, in seconding the motion, said that he did not share Prof. Lapworth's roseate views, as mining in this country was handicapped by obsolete machinery, and we had to go deeper and deeper for the coal. However clever they might be, it scarcely seemed sensible to think it possible to mine coal at great depths at the same cost as they could by a level driven into the side of a hill. The cheapness of the United States coal arose from the fact that from the first blow of the pick the mine began to be remunerative. But was cheap coal the philosopher's stone that some people considered it to be? Germany was producing steel, in competition with Great Britain, and the cost of coke in that country was greater than in this.

Prof. R. A. S. REDMAYNE, in supporting the motion, remarked that the President had drawn a picture of the coal-mine of the future, and it might be that the picture was not so much over-drawn. A short time ago, he had the pleasure of hearing an address by Mr. J. B. Simpson on the possibility of producing a new coal-field below the existing coal-field of Northumberland and Durham. During a recent visit to the United States he had seen ore drawn in Michigan from a copper-mine at a depth of 5,000 feet, and the temperature was by no means excessive. He believed that it was contemplated to draw from a depth of 7,000 feet, and engines were being erected for drawing from a depth of 6,000 feet.

The motion was cordially approved.

DISCUSSION OF MR. J. H. WHITTAKER'S PAPER ON "SPARKLESS ELECTRIC PLANT FOR USE IN MINES AND IRONWORKS."*

Mr. S. L. Thacker said that he had read Mr. Whittaker's paper with much interest, and these remarks were made, not merely for the sake of criticism, but rather that the subject might in some degree receive a discussion commensurate with its importance. While there would probably always be special conditions individually suited to both continuous and polyphase systems, he (Mr. Thacker) was in agreement with most of the advantages of the latter as set forth in the paper; but, at the same time, it might be of service to members that some of the points dealt with should receive further consideration.

Take for instance capital expenditure:—At the present time, a polyphase plant was more costly than a continuous-current plant of the same power; the generator required a subsidiary dynamo for the excitation of the field; switches and switchboard gear were somewhat more complicated; and it was his (Mr. Thacker's) opinion that the cables would also be found to be more expensive. Mr. Whittaker stated in his paper that, although three wires were necessary, there would be a considerable saving of copper, as the gauge would be smaller owing to the adoption of a higher voltage. Now, in the case of alternating currents, the voltage followed a wave-curve having a periodicity of 45 to 80 per second, and the pressure at the peak of the curve would reach fully 50 per cent. above the mean or effective pressure, and to this was mainly due the fact that shocks from an alternating current were more dangerous than from a continuous current. Obviously for the same comparative safety, the effective pressure must be lower than in the case of continuous current, and for the same efficiency, the weight of copper would be nearer 50 per cent. more than 50 per cent. less. With regard to the author's remarks as to the use of transformers, the above considerations would prevent the adoption of any such voltage as would necessitate their use.

Coming to the principal feature, the sparklessness of the motors, here undoubtedly was an advantage, not so much from the absence of sparking, but because burning of commutators meant expensive repairs and renewals of commutators and armatures.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 170.

It was his (Mr. Thacker's) contention that the danger of ignition of gas at the commutator was largely exaggerated and was far exceeded by dangers from breakage and short-circuiting of cables and switch-gear, which contention was borne out by the reports of H.M. inspectors of mines. Motors in mines, usually work somewhere near the floor, and for ignition to occur at the commutator, the motor must be at work practically surrounded by an explosive mixture; surely such a condition of things was scarcely likely to occur in any well-regulated mine, apart from a very sudden outburst of gas. On the other hand, supposing that cables were taken along a dry and dusty main haulage-road, a bar might break and a fall occur raising a cloud of dust, breaking the cable and causing an arc, not a remote contingency; the result might either be a fire or an explosion. In such a case, polyphase current had no advantages.

Undoubtedly the system enjoyed greater immunity from breakdown and a less cost of upkeep, and he (Mr. Thacker) thought that these were the considerations which should be urged in favour of its adoption. A great desideratum of colliery-machinery was that it should keep going, and it did not require many stoppages to absorb the increase in first cost. Whatever the system adopted, it would be found economical to provide a thoroughly reliable installation, under systematic and capable supervision.

Electricity would play no small part in the future in lessening the cost of production of the deeper and thinner seams, and while it was of the utmost importance that the safety of human life should be ensured, it would be a misfortune if its use were retarded by any arbitrary or unpractical enactments. A Government Departmental Committee was at present engaged in investigating the dangers attending the use of electricity in mines, and presumably they would make certain recommendations: was the time not opportune for some suggestions being made by those who were most intimately acquainted with its dangers and advantages? With a view of obtaining an expression of opinion, he (Mr. Thacker) suggested that the following rules should be adopted where electricity was employed in mines:—

1. Where electricity is used for power purposes in mines, a competent person, appointed by the owner, agent or manager for the purpose, shall once in every 24 hours, examine the state of the dynamos, motors, cables, switches and similar

appliances aboveground and belowground ; and a true report stating what defects, if any, were observed, and what steps were taken to remedy the same, shall be recorded without delay in a book to be kept at the mine for the purpose, and shall be signed by the person who made the inspection.

2. If in any mine at either of the inspections under General Rule 4, inflammable gas has been found to be present in any ventilating district where electricity is in use, the current shall immediately be completely switched off from all cables and appliances whatsoever between the place where the gas has been found and the return-air course ; and the current shall not again be switched on until the competent person appointed under General Rule 4 has examined the place where the gas has been found, and has certified that the accumulation has been cleared away.

Mr. Isaac Meachem, jun., remarked that the danger of ignition of gas had been exaggerated ; and he had found that the chief trouble arose from the water in a mine.

Mr. H. W. Hughes said that the three-phase system would eventually supersede every other method of generating electricity, and of the large plants, erected within recent years, 90 per cent. were working on the three-phase system. He had recently visited a large works on the Continent, where the waste-gases from the blast-furnaces were working large gas-engines, driving three-phase generators producing a current of 10,000 volts which was conveyed 5 miles to the steel-works.

Mr. Isaac Meachem, jun., said that Mr. Hughes might be right in stating that the three-phase system was the best for large installations; but he (Mr. Meachem) maintained that the continuous-current system was the most suitable for the small plants used at collieries.

Mr. J. H. Whittaker wrote that Mr. Thacker's statement that polyphase machinery was more costly to install was not correct. There might not always be a great difference, but if really representative prices were considered, the difference in cost, be it large or small, would be generally in favour of polyphase machinery. In some cases, however, the difference was very great, and he knew of an instance where about £400 was saved in a £1,000 plant.

The alleged complications of the three-phase system disappeared when the principle of the system was once grasped. The exciter was directly coupled to the alternator, and practically required no attention in comparison, say, with a continuous-

current generator, which was carrying the whole load of the mine, instead of the fractional current necessary to energize the fields of the alternator. The switch-board might be as simple as the older system, and in both it was simply a matter of design. Voltage-considerations as to shock-risk did not enter as a limiting factor into the saving of copper in the main. The maximum pressure in an alternating current was higher than the normal working pressure, but it must be remembered that with continuous current, at a pressure of 500 volts, the cables must be covered and danger notices were necessary, as even cables carrying 500 volts must not be touched. Now with a polyphase current of 5,000 volts, it was just as simple, "You must not touch"; and it was almost as easy to insulate the cables, especially as they would be of much smaller diameter. A very important difference between the two motors was, that with a three-phase 5,000 volts motor, the current was simply carried by the insulated cables and windings in the stationary part of the machine, whilst on the rotating portion, commonly called the armature, there was no high-pressure current. This was due to the fact that the motor-currents had no connection with the line-voltage or mains, and the current carried was only an induced current amounting to from 10 to 300 volts. With a 5,000 volts three-phase motor, there would be no bare metal carrying more than 10 to 300 volts (varying with the size, that is, about 100 volts in a motor of 100 horsepower) while with a continuous-current motor at 500 volts, the commutator and brushes, which were parts that had to be handled, exposed the full 500 volts for ready shocks; consequently, in practice the 5,000 volts motor was quite as safe as the lower-pressure motor.

He (Mr. Whittaker) stated in his paper that he did "not think that there is a case on record of gas having been fired by the sparks from the motor-brush." He did not think that there was great risk in using a continuous current, and for very small mines and powers, the mining engineer had better use continuous currents than no electricity at all. Mining engineers had fought shy of man's great servant too long already, and electricians must not attempt to reveal a bogey, where one was not in existence; but the break-downs, burn-outs, and wear-and-tear were very real troubles. When engineers remembered that these troubles could be overcome, and that whatever continuous currents

could do, in the way of power-transmission, three-phase currents could do better as a general rule, they might be willing to study the question, and indeed must do so, if only from considerations of our future as a commercial nation.

Polyphase machinery was not best for every purpose, and there were many conditions, especially where lighting was a great consideration, where continuous currents might be most suitable; but for all power-work, where the motors were a long way from the surface, where the currents were carried long distances, where large powers were developed at the generators, and distributed amongst many small motors, where a number of small steam-engines could be superseded and one large one operated, or large gas-engines, at a central station used to generate electricity and transmit it over many miles, in the pit, works, factories, towns and even villages, here polyphase electrical distribution might prove itself to be the most economical.

Mr. S. L. Thacker desired to remove a slight misapprehension, as he was not a partisan of continuous or of three-phase current. He had only desired to point out that the advantages of the three-phase system lay rather in less liability to breakdown and lower working cost than in immunity from ignition of gas. Of course, on the surface, there was practically no limit to the voltage which might be employed within the possibilities of insulation, but it would hardly be economical practice to take high pressures down the shaft and transform them at the pit-bottom, and the carrying of 3,000 or 4,000 volts along the roadways of a mine would entail serious responsibility upon the management.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, DECEMBER 8TH, 1902.

MR. T. J. DAVIES, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. T. G. GATIS, Mining Engineer, Wolverhampton.
Mr. LAWRENCE HOLLAND.
Mr. G. R. MORGAN, Assistant Mining Engineer, Llanelly.
Mr. J. T. ONIONS, Colliery Manager, Wolverhampton.
Mr. E. H. ROBERTON, Mining Lecturer, The University, Birmingham.

DISCUSSION OF MR. DANIEL JONES' PAPER ON "LEGISLATION AND THE OWNERSHIP OF PROPERTIES CONTAINING COAL."*

Mr. W. N. ATKINSON (H.M. Inspector of Mines), with reference to the proposal that there should be some State authority, similar to the Railway Commissioners, to regulate the granting of mineral leases, wrote that the first question that suggested itself was whether the national interest in the duration of our coal-supplies was such as to warrant interference with the private rights of the owners of mineral properties? If that question were answered in the affirmative, he (Mr. Atkinson) thought that there would be no difficulty in showing that such State-regulation would be of national benefit, and need not necessarily be detrimental to the financial interests either of lessors or lessees. The scope of the proposed authority should be wider, than merely to intervene

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 272.

with reference to small properties in such cases as those mentioned by Mr. Jones in his paper. For the most beneficial working of a coal-field and the prevention of waste of minerals, the geological and engineering features of the district should be taken into consideration, and the areas worked by the different mines should not be controlled, as at present, only by surface-boundaries. In many cases, there would probably be no reason for such an authority as was suggested to interfere with the arrangements proposed to them by lessors and lessees, though in other cases their interference would be of the greatest importance not only to individual mines, but for the beneficial working of the coal-field as a whole.

The PRESIDENT (Mr. T. J. Davies) thought that the question raised by Mr. Jones was of national importance. It often happened that in the devising of some beneficial scheme, plans and arrangements had to be altered through the proprietor of some small intervening area adopting an unreasonable attitude. The appointment of such an authority, as was suggested, would lead to the proper and economical working of our coal. It would facilitate matters if the Royal Commission on Coal-supplies would take up the subject, which certainly should not be allowed to remain in its present unsatisfactory condition.

Prof. CHARLES LAPWORTH stated that the Royal Commission had the subject under their consideration.

Prof. R. A. S. REDMAYNE referred to the scheme proposed by the late Sir George Elliot, by which the question of wayleaves, barriers, management, etc., would be much simplified. This scheme—which was to be a kind of national coal-trust—was made public in September, 1893. Sir George Elliot estimated that an average selling price of 7s. 3d. a ton at the pit-mouth would be ample, at the then annual rate of output, to yield returns of 5 per cent. on the debentures, which were to form one-third of the capital of the trust, and from 10 to 15 per cent. on the ordinary stock, which was to constitute the remaining two-thirds of the capital. Independently of this return on capital, there was to be a sinking fund for the redemption of capital, so as to ensure the permanency of the consolidated property. These remarks were likely to be of interest in view of the subject of Mr. Jones' paper, though he was

not by any means an advocate of such a trust as that which had been sketched out by Sir George Elliot.

Mr. W. B. Collis thought that the subject required further careful consideration before it would become ripe for legislative enactment. It would be of great advantage if some court were established, that could be asked to intervene when necessary between the owners of adjacent mineral estates.

Mr. Isaac Meacham, jun., agreed with the proposal that there should be an authority with powers to intervene between the owners of neighbouring mineral properties. In addition to the private rights of the various owners, there were what he would call "shadowy rights," which should also be investigated.

Mr. Alexander Smith said that he was connected with an estate where the lease of a large area of coal had been kept in abeyance for 3 or 4 years, as they had experienced considerable difficulty in acquiring small intervening areas. Although the lease had been completed and operations had been commenced, there was still an important area unacquired through the "dog-in-the-manger" action of the owner, and it might ultimately be lost to the nation. The principal intention of Mr. Jones' paper, as he took it, was to draw the attention of the Royal Commission to the subject, and that had been accomplished, as they had heard from Prof. Lapworth that the matter was receiving their attention; and as to two of their prominent members, Prof. Lapworth and Mr. Arthur Sopwith, were members of the Commission, they might safely leave the matter in their hands.

Mr. D. Jones, replying to the discussion, said that he was quite aware that the suggestions which he had made would take most of the owners of property containing coal by surprise. The subject had not been much before the public, except as a proposal to nationalize all mines. It was a constant subject of discussion at the Trades Union Congress. Mr. Pickstone had recently read a paper before the Manchester Geological Society, favouring such a view, and Mr. Arnold Lupton, whose opinion, would weigh heavily with mining-engineers, adopted a similar view. He (Mr. Jones) asked the members to bear in mind that his proposal took only the form of compulsion in cases where the owner was utterly unreasonable, and no attitude was better calculated to force on the

idea of the nationalization of mines. He (Mr. Jones) asked merely that the owner should be forced by law to submit his case for decision to a tribunal of suitably chosen, competent, and impartial men. The Royal Commission on Mining Royalties touched upon the subject, but dealt with it as though no great need for legislation had yet arisen. The existence of a Commission on Coal-supplies, who were now taking evidence, seemed to afford the opportunity of an enquiry being made, and if their report did not refer to this subject it would be incomplete. For it would be an absurdity to make an estimate of the coal contained in this country unless it could be worked. If it were true, as he (Mr. Jones) had stated, that in a single instance a property of 2,000 acres containing 100,000,000 tons of coal was locked up, how much might lie in properties similarly situated throughout the country?

The questions might now be asked: Is the case proved? and, if so, has the time arrived for an enquiry? and the need or not for legislation would follow upon the result of that enquiry.

The trouble of scarcity of coal would not come all at once as a bursting cloud, but it would be felt in district after district, and it would crawl up unobserved. In the South Staffordshire coal-field, furnace and manufacturing coal was already being imported from other coal-fields. The Mines-drainage Commission had a severe struggle to keep down the water, and year by year the difficulties would become greater as the output became reduced. If from any cause that Commission were dissolved, there would be a sudden abandonment of the old Staffordshire coal-field. A most important group of manufacturers was established in that district, which they were accustomed to call "the allied trades," having regard to the principal operations of ironmaking. Even if the heavy export trade in iron had been displaced by reason of costly freights to the sea-ports, these allied trades would continue to form a great home market for iron, steel and coal, if a supply of the latter could be assured.

It would be too late to make an enquiry, after these trades had left the district. Including the preliminary boring, the sinking of shafts, and the equipment of a deep colliery, some seven or eight years would be taken up. If no enquiry were made by the Royal Commission on Coal-Supplies, they might have to wait another 30 years, unless a Special Commission were appointed to make such an enquiry.

Whatever might be said as to large proprietors in other parts of the country being only too willing to subject their properties to mining operations, it had been shown that it was not so in their immediate district.

It had been urged that the question was a very large one, involving a large amount of investigation, but this labour should not present itself as an obstacle to the enquiry. He was aware that there would be active opposition from mineral landlords, but old ideas must give place to new, and private interests to national interests. The authority he would suggest would be a group of experts, men whose opinion the land-owners would respect, and to whom they could refer with confidence: and a land-surveyor would be a useful member. He thought that his suggestion was not an unreasonable proposition nor a harsh one. The fact that there would be areas of coal left unworked under the present system would be one of the strongest arguments that the working-classes could advance for the nationalization of mines.

Mr. W. F. Clark said that the subject of Mr. Jones' paper was an important one, but he should require much more definite evidence to prove the necessity for the creation of such an authority as that suggested by Mr. Jones. He had not, in his experience, come across, or heard of, any large area of coal that was likely to be lost.

Prof. R. A. S. Redmayne read the following paper on "The Training of a Mining-engineer":—

THE TRAINING OF A MINING-ENGINEER.

By R. A. S. REDMAYNE.

It is interesting to compare the present status of colliery-managers with the position and requirements of those in the early history of the coal-trade.

Retrospective.—In that quaint little volume, perhaps the earliest treatise on colliery-management in the English language —*The Compleat Collier: Or, The Whole Art of Sinking, Getting, and Working, Coal-Mines, &c. As Is now used in the Northern Parts, Especially about Sunderland and New-Castle*, by J. C., and printed for G. Conyers, at the Ring in Little-Brittain, 1708—the writer says that a viewer "ought to be well skill'd in this great Concern he takes in his Hand, he ought to know Lineing, and Levelling well, as also the Method of Coal-Working, together with the Knowledge of the Nature of the Coal; for there is very great Occasion for all these four Qualifications,"* and adds that "it behoves the Viewers and Over-Men to be experienc'd in guiding the Air to good Purpose, as also to Order well and Prudently for Styth, which I before spoke of, doth Destroy the Ignorant and Unwary."†

The charge of a colliery-manager in those days was not an excessive one, seeing that, though he might have a number of mines under his control, in no case would any one of these extend beyond a radius of 600 feet from the shaft. His wage was correspondingly small, he having "evidenc'd both his Care and Parts in the Respects I have mention'd, and well deserved his 15s. or 20s. per week, or more, as he has Pits to look after."‡

Mr. J. B. Simpson, writing of the term "viewer," says:—"The first mention I can find of the old name is in 1356, in a lease from Bishop Hatfield to one Thomas Gray, Knight. One clause states that the lessee had to work the mine as far as it could be wrought by five barrowmen according to the view and oath of the chief forester and of the Viewer, spelt 'Veiour.'"§

* Page 35. † Page 39. ‡ Page 38.

§ *Rise and Progress of Coal-mining: An Address delivered to the Newcastle-upon-Tyne Association of Students of The Institution of Civil Engineers*, 1896, page 7.

And again, in 1699, in a letter in Mr. J. B. Simpson's possession from the Hon. Charles Montagu (who was an owner of Benwell and other collieries) to his land-agent, he says:—"Viewers' opinion, which I look upon to be like a consult of Physicians, never used but in desperate cases and to no purpose. However, it gives some satisfaction then."*

To refer again to our friend, *The Compleat Collier*, he says "both the Officers and poor Miners, are in dayly Peril and Hazard of their Lives, for a poor Livelyhood, and that they may be easily Destroyed by Ignorant and Unskilful Managers, from which sudden and sad Misfortunes, I heartily Pray, *Libera nos Domine*."†

Coming down to a much later date, we find in an "opinion" hitherto unpublished, written by Mr. John Buddle, senior, a viewer of great note in the latter half of the eighteenth century, the following definition of the duties and salaries of an agent and viewer respectively. On March 22nd, 1830, Messrs. Donkin and Stable write to Mr. Buddle, to the effect that the owners of a "Seasale colliery upon the Tyne, of considerable magnitude (the basis of its vend for 1828 being between 22,000 and 25,000 tons)" are about to make a change in the agency of the colliery, and are desirous of having his opinion with regard to the system which he deems most advisable to be pursued in the management of such a colliery; and the number of agents he would recommend to be employed, their duties, etc. Mr. Buddle answers that he is of the opinion "that the affairs of the colliery would be best conducted by one principal agent or manager, and one principal viewer, with the aid of subordinate assistants in their respective departments." The agent is to have the management of the fittings (sales) and all cash transactions of the concern, purchases, etc. The viewer or manager "to have the sole management and direction of the colliery in all its several departments, embracing the machinery, etc., from the hewing of the coals to their delivery into the ships." He adds, at a later date (April 5th, 1830), that for an agent "a salary of £250 or £300 a year, with house and fire, and a cow kept, would be fair and ample . . . . as to the viewer, if not resident, I think a clear annual salary of £200 a year fair and reasonable, without any perquisites whatever except his flannels."

* *Rise and Progress of Coal-mining: An Address delivered to the Newcastle-upon-Tyne Association of Students of The Institution of Civil Engineers*, 1896, page 7.

† Page 39.

In 1835, the position of a colliery-manager is thus described in *The History and Description of Fossil Fuel, the Collieries and Coal Trade of Great Britain*:—"The general direction of a large colliery, as to the scale and description of its workings, and also with regard to whatever requires a profound theoretical as well as a complete practical knowledge of obtaining the coal economically and safely is in the North confined to persons called viewers.' Not a bad epitome of what is looked for in a colliery-manager of the present day.

And in the *Minutes of the Committee on Education, 1840-1841*, "latterly the work of a viewer has been regarded as a profession requiring regular training, and the grades of society are becoming more strongly marked."

Even so late as the year 1854 we find that the largest collieries were comparatively small affairs, the output from the largest amounting only to about some 200 to 300 tons daily, although they were equal to drawing "from 400 to 500 tons daily at each pit."* The number of the workmen and the nature of their employment at two large pits at this period are shown in the Appendix. It is interesting to compare this statement with the establishment of a large modern colliery, and the comparison illustrates, as well as anything, the great extension that has taken place since the middle of the last century.

The Present Day.—The object of the writer in thus briefly reviewing the past, is to emphasize the developments that have taken place; to show that, parallel with the expansion of mining and consequent increase in the responsibilities and obligations of those to whom the management of mines is entrusted, there has been an ever growing necessity for further scientific education of the latter. "The old order changeth, yielding place to new," and the law of evolution is at work in the domain of mining, as in all else; and if there is not progression, there is retrogression. There can be no such thing as standing still.

What are the qualifications demanded of the colliery-manager of the present day? This question cannot be better answered than in the words of Mr. T. E. Forster Brown, who, speaking to the

* "The Extent and Probable Duration of the Northern Coal-field; with Remarks on the Coal Trade in Northumberland and Durham," by Mr. T. Y. Hall. *Trans. N.E. Inst.*, 1854, second edition, vol. ii., page 196.

members of the National Association of Colliery Managers, said: "The colliery-manager of to-day has to grapple with very different problems from those which he had to grapple with in those days [1860]. We have to deal with the working of coal at very great depths, and we have to deal with labour under very serious and stringent legislative enactments. Colliery-managers now require to be first-rate organizers, not only with regard to labour, but in other matters; and, in fact, the successful colliery-manager of the present day is an entirely different person from what he was 30 or 40 years ago. The ideal colliery-manager . . . ought to be a scientific philosopher, with a thoroughly practical knowledge of mining and of men, and of applied mechanics. He ought to have great firmness of purpose, great perseverance, and . . he ought to have a good digestion."*

A large modern colliery with its extensive equipment, including the varied appliances for getting coal and bringing it to the surface, for the transmission of power over long distances, especially underground, for causing vast volumes of air to flow through miles of confined passages, for draining large areas of underground workings and raising the water to the surface, for screening, cleaning and washing the coal, presents, as has been well said, "one of the most remarkable specimens of human activity and its triumph over matter."

It will be everywhere acknowledged that more scientific knowledge is now requisite to deal with the larger issues at stake at the present time or looming ahead of us. Briefly summarized, the necessity for this increased and increasingly higher education of our mining managers may be stated as being due to the following facts:—(1) The mines are deeper, the more easily worked seams and shallow mineral deposits are rapidly approaching exhaustion; and (2) deeper and more difficult mining, as well as developments in engineering, has led to the introduction of more elaborate machinery, necessitating a wider knowledge of the principles underlying its construction, application and management. Especially notable under this category is, of late years, the application of electricity to many mining operations. (3) Foreign competition, which growing in keenness, necessitates, wherever possible, the introduction of labour-saving appliances, and of anything that tends to cheapen production. (4) Stringent State regulations imposed

* *Transactions of the National Association of Colliery Managers*, 1894, vol. vi., page 311.

in a great measure for the protection of the persons and interests of the miners. (5) The higher educational status of the mine-workers, rendering tact, discrimination and higher mental attainments necessary in those set in authority over them; and (6) the great and increasing development of colonial mining, opening out, as it does, a wide field of profitable employment for highly-trained mining-engineers.

And under this final category, it is significant that in respect to metal-mining, the leading positions in South Africa, Western Australia, and other of the Australian colonies are not held in the majority of cases by British or Colonial trained mining-engineers, but by men trained in the United States of America. Briefly stated, this preference for American rather than British trained engineers may be said to be due to the American having a more thorough scientific training, leading to the knowledge of the principles underlying engineering operations, an intimate acquaintance with mining appliances, gained first at college, and then in the mine, and an ability to turn his hand to anything. In this adaptability of the American, lies his advantage in a great measure over the Briton. It may be due to racial characteristics engendered by his having to battle with constantly changing circumstances, but in the case of mining-engineers, at any rate, it undoubtedly receives further development by the nature of their collegiate training. In Great Britain, we still produce the best colliery-managers, but then our coal-mines are more difficult to manage than are those in the United States, by reason of the greater depths and thinner seams. Yet even in this department of mining, we would seem to be losing our proud pre-eminence. Up to 1899, we held the position of being the largest producers of coal of any country in the world; but in that year the United States wrested this position from us with an output of 226,554,000 against 220,094,781 tons, the production of Great Britain, and this position she still holds, with an output for the year 1901 of 260,929,000 tons, as compared with our output for the same year of 219,046,945 tons.

It may be said that this is no criterion of the relative merits of American as compared with British mining-engineers, but it is a significant fact that whereas coal-cutting by machinery is on the wane in Great Britain, it is on the increase in America, as the following figures show:—

	United States.			Great Britain.	
Years.	No. of Machines.	Tons of 2,000 lbs.		No. of Machines.	Tons of 2,240 lbs.
1899	3,125	43,963,935	...	?	3,538,408
1900	3,907	52,784,523	...	311	3,312,000
1901	4,341	57,843,335	...	?	3,044,340

In ten years, from 1891 to 1901, the number of coal-cutting machines in the United States had increased from 545 to 4,341.

It may be argued that the conditions prevailing in the coal-fields of the United States are such as allow of the proportionately larger introduction of coal-cutting machinery, but, can it be maintained to such a relatively greater extent? It would seem, therefore, that what we might copy from the Americans in matters relating to mining, and indeed in other departments of engineering, is their readiness to adopt wherever possible, labour-saving machinery. It must not be supposed that the writer is for one moment an advocate for the adoption of American methods in their entirety, but he takes the position that we should be willing and anxious to learn what we can from anyone, more especially from our chief competitors.

There is one point in respect to the training of mining-engineers in which, he believes, we are in advance of Americans, though they hold otherwise, and that is, in respect to our apprenticeship system. There is no mining apprenticeship in vogue in the United States, but, he would ask at the same time, are we not possibly erring on the side of excess in this matter? For the five years underground practical experience required by the Coal-mines Regulation Act of 1887, before a mining student can sit for his certificate of competency as a colliery-manager, practically precludes the possibility of his obtaining, at a college, the scientific training, so necessary at the outset of a mining-engineer's career, to fit him for the effective management of mines (coal and otherwise) now required.

In coal-mining, the Americans have, and will for many years have, the great advantage over us in that they are possessed of vast stores of coal lying close to the surface; and that their mining-engineers are capable of also dealing most effectively with the problems introduced by deep mining is proved by the fact that they have the deepest metalliferous mines (and deeper than any coal-mine) in the world, which are at the same time among the best and most economically managed mines throughout the globe.

There are in the United States and Canada 37 institutions, which are either devoted entirely to mining instruction, or have a mining department:—34 of these are in the United States and 3 in Canada. The following is a list of the more prominent:—

United States of America:—

- **The University of California: College of Mining.**
- **Harvard University: Lawrence School of Mining.**
- **University of Minnesota, Minneapolis.**
- **University of Missouri.**
- **Columbia University, New York.**
- **Ohio State University (specializes in coal).**
- **Lehigh University, Pennsylvania (specializes in coal).**
- **Colorado State School of Mines.**
- **Massachusetts Institute of Technology, Boston.**
- **Michigan College of Mines.**
- **Ann Arbor University, Michigan.**

Canada:—

- **McGill University, Montreal.**
- **Kingston School of Mines.**
- **Toronto School of Mines, Ontario.**

During a recent tour of inspection in America, in company with his colleague, Prof. Turner, the writer visited four of the more prominent (from a mining point of view) of these schools; he was privileged in being allowed by the authorities to inspect in detail, the mining department of each; and he was afforded every possible information and assistance in his inspection. He was most struck with the lavishness and completeness of the equipment, there being nothing comparable to it in Europe; with the very practical nature of the training, based upon a thorough scientific groundwork, to which the mining students were subjected; and with the number of students who availed themselves of the opportunities of instruction thus afforded to them.

The graduation-course at nearly all these mining colleges extends over four years, and practically the whole of the students enter on the full course of instruction with a view to graduation. The matriculation examination is of a difficult character, similar as to nature and severity of the subjects to that of the University of Birmingham.

The training to which students are subjected does not vary greatly in the principal colleges nor the nominal age at which students enter, which is usually 18 years, though, if well equipped physically and mentally, so as to be able to stand the strain, they are allowed to enter even younger than this. The average age,

however, at Columbia University, for instance, where there are 160 (1901-1902) mining students, is about 19 years. It has been found at these colleges that an earlier age, say 15 years, was too young, as the students could not then appreciate the seriousness of the work they had to do.

The first, and, in many instances, the first and second year, is devoted to a thorough grounding in the elements, at any rate, of pure science (mathematics, geology, chemistry and physics), as well as in foreign languages. This is followed by a course of applied science. Much of the third year is spent in the mining laboratories, where the students are divided up into squads, under the care of the professor or his assistant-professors. In this work, the professors endeavour to reproduce in miniature every typical process, etc., possible of reproduction in a mining laboratory. In the fourth year, the student selects the subject of his thesis, which he has to send in in order to obtain his degree. A variety of subjects is open to him to choose from, to quote some actual and recent instances:—Two students selected washing of coal; two copper-smelting; and four ore-dressing. Two men may, if they like, work on a thesis together. At the Columbia College of Mining, the student is given an imaginary property to develop; topographical and geological details are stated, and from these he has to open out and develop the property into a going concern producing so many tons per diem. He has to show the cost, and the time taken in bringing the mine to the producing stage, apportioning the time and cost to the various stages of development; and to produce detailed drawings of some of the principal parts of the plant. And besides this thesis work, he has to continue his attendance at lectures.

In a conversation which the writer had with Prof. H. S. Munroe, chief of the Mining Department at the Columbia University, the latter emphasized three special points, placing them in the following order:—(1) Thorough groundwork in the sciences allied to mining (mathematics, physics, chemistry and geology). (2) Thorough training in the special department of applied science which the student intends adopting as a career; and (3) competence of the student to commence earning a livelihood at once on his leaving the University.

Besides the indoor work, there are summer schools of surveying and of mining. For the former, a district is chosen, the topo-

graphical details of which are at once very varied and contained within a limited area, so that much and detailed work may be accomplished. This school, in the case of Columbia, extends over 12 weeks. About 2 weeks' continuous attendance is required of each class between the first and second, and the second and third years, and 4 weeks between the third and fourth years. The latter, or school of practical mining, includes 6 weeks spent in detailed study of the plant and methods of working at some important mine or mines; in geological work, surface and underground; in mine surveying, etc.

Special courses, consisting of personal instruction, reading and research work, are arranged for advanced students according to their individual needs and ability--that is, post-graduate work.

As has been previously mentioned, there is no pupilage-system in Canada or the United States. On leaving college, the students pass at once into active employment, indeed, during vacation many of them are sometimes so engaged, and are encouraged to do practical work. The writer was assured that no difficulty was experienced in obtaining situations for graduates in subordinate positions as mine-surveyors, mine-bosses, and the like. Prof. Bovey, the Dean of the Faculty of Applied Science at McGill University, said that he had from 20 to 30 more applications for men from the heads of engineering undertakings than he could supply. This year, one of his graduates accepted a post of a value equivalent to £1,000 per annum as a mine-manager, without having been, previously, permanently employed at a mine.

The writer found that in respect to the large mines, although the mining-bosses (the equivalent of our undermanagers) were frequently men of no college training, but had, in many cases, worked their way up from the position of workmen, the chief agents, on the other hand (who might be termed the brains of the concern) were invariably college-trained men, and were often quite young, from 25 to 30 years, and in receipt of large salaries; much larger than those paid in this country to men occupying similar positions.

Prospective.---What is of greater importance to us is the question, what is being done in the way of higher education for the mining-engineers of Great Britain? For though in pure science we are still pre-eminent, it seems to the writer that there is this great difference. The American mining-engineers are subjected

to greater thoroughness in technical training than are our men. Better facilities, in this respect, are placed before them, and realizing the paramount importance of such training, they take greater advantage of it than seems to be deemed necessary in this country. Technical education is held in higher regard by the owners of mines and other industrial concerns in America, than is as yet the case in Great Britain. Anyone who has read the accounts of what is done and provided in the United States and contrasts the magnificent educational apparatus of their universities with the scanty system, or want of system in this respect in this country, will no longer be at a loss to understand one reason why the British mining-engineer, who seeks employment in our Colonial mining regions, is handicapped in the race for supremacy.

At Birmingham, at any rate, it is hoped that this deficiency will be remedied, and the writer believes that it will be so, with the assistance of the mining-engineers of the Midlands. Much good work has been and is being accomplished by the County Council lecturers in mining in the Midlands, and this will undoubtedly be the means of inducing many of the young men who benefit by such instruction to proceed to the University with the view of further advancement in this department of study.

The mining department of Birmingham University has been founded by the authorities in order to meet the requirements of the large mining community of the Midlands, and at the same time to afford mining men, from other parts of Great Britain and the Colonies, theoretical and practical instruction in the various branches of mining—for a complete mining department should include instruction in both branches of mining—coal and metalliferous. Coal-mining students will undoubtedly constitute by far the largest and most important class, those attending this course of instruction being chiefly intending colliery-managers, drawn from the surrounding and other coal-fields. The students of metalliferous mining will be mainly derived from the Colonies, those who intend proceeding to the Colonies and foreign countries, and some few from the metalliferous mining-districts of Great Britain. There will also be a class of students who intend practising as general mining-engineers, who will take up both branches of study.

In an ideal mining school, such as one would wish to see established at Birmingham, the laws of ventilation, the modes of working, of timbering, of haulage (underground, etc.), would be demon-

strated in a model mine, and one would wish that some one would present such a sum to the mining department of this University as would allow of its construction. Coal-washing, surface-arrangements at collieries and metal-mines, mining tools, the construction and testing of safety-lamps and blasting materials, would all be shown in this ideal mining school, as well as the demonstration of the principal modes of dressing, in operation at metalliferous-mines (which now constitutes an essential adjunct to every mining department in leading American colleges). The working of drills and coal-cutting machines, the manner of testing the safety of explosives in gaseous mixtures and mixtures of coal-dust, would also constitute an integral part of the equipment. Advanced students would be encouraged to carry on useful research-work dealing with the problems of underground ventilation, colliery-explosions, coal-washing, ore-dressing, coal-cutting and the like. Much of this, it is hoped, will be carried out at the Birmingham University.

As it is, courses of study have been arranged, and are already being conducted for practising and consultative mining-engineers, colliery-managers, managers of metalliferous mines, teachers of mining and mine-surveyors. The complete mining course includes instruction in the following subjects:—(1) Mathematics, including algebra, trigonometry and geometry; (2) inorganic chemistry with laboratory practice; (3) geology and mineralogy; (4) physics and laboratory practice; (5) mechanical and electrical engineering; (6) coal and metal-mining; and (7) metallurgy and assaying, so far as applied to the treatment of ores, and the analysis of fuels.

Besides indoor work, there will be frequent visits to the mines of the neighbourhood, and occasional surveying classes will be held out of doors, in which the students will practise what they have learned theoretically, and 4 or 5 weeks will be devoted by the students each year in company with the professor, to the inspection and study of some group of mines in Great Britain or abroad, which will constitute the summer mining school.

In conclusion, the writer maintains that if only we will take heed of the fact that the day for the rule-of-thumb man has passed, that the necessity of a scientific education is an ever increasing factor in the training of practical men, and that our chief industrial competitors, Germany and the United States,

have already realized this fact, and are acting accordingly, there need be no cause for despondency, nor any reason why we should not continue to hold our proud position as the producers of the foremost captains of industry, mining and otherwise, in the world.

APPENDIX.—TWO UNDERGROUND ESTABLISHMENTS IN THE COUNTY OF DURHAM IN 1854.

Name of Colliery. Output per Annum.	Haswell Colliery. 200 000 Tons.				Towneley Colliery. 100,000 Tons.			
	Men	Boys	Men	Boys	Men	Boys	Men	Boys
1. Staff (for safety) employed in superintendence, and in properly ventilating the mine and waste, in keeping roads, setting timber, removing obstructions, and doing all things necessary for the safety of the mine and the workmen :—								
Overmen	2	0			2	0		
Back-overmen	2	0			1	0		
Deputies	23	0			10	0		
Inspectors	2	0			1	0		
Wood-leaders	0	3			0	2		
Trappers	0	7			0	4		
Rolleyways	7	2			0	1		
Furnace-men	2	0			1	1		
Safety-lamp keepers	2	0			1	0		
Shifters	12	0			2	0		
Wastemen	8	1			1	0		
			60	13			19	8
2. Bargainmen employed in stone-drifting, cutting through troubles, etc., generally by piece or bargain work	12	0			4	0		
			12	0			4	0
3. Transit of coal underground :—								
Putters	0	44			0	28		
Couplers and loaders	0	12			0	2		
Switch-keepers	0	10			0	1		
Horse-drivers and pony-drivers ...	0	38			0	10		
Inclines	0	12			0	2		
Horse-keepers	2	2			1	0		
Brakesmen, underground ..	2	2			2	0		
Firemen at engines	0	2			0	0		
Onsetters, and greasers	3	4			2	2		
			7	126			5	45
4. Employed in cutting coal	210	0			98	0		
			210	0			98	0
Totals			289	139			126	53

The PRESIDENT (Mr. T. J. Davies) proposed a vote of thanks to Prof. Redmayne for his paper.

Mr. W. B. COLLIS seconded the proposition, which was cordially approved.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,
HELD AT UNIVERSITY COLLEGE, NOTTINGHAM,
DECEMBER 6TH, 1902.

Mr. G. ELMSLEY COKE, PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBER –
Mr. STUART MCMURTRIE, Halesowen, Birmingham.

STUDENTS—
Mr. JOHN DICKINSON, c/o Mr. A. Hunter, New Tupton, Chesterfield.
Mr. ALBERT ALFRED PEAKE, Holywell House, Codnor.

DISCUSSION OF MR. G. A. LONGDEN'S PAPER ON "CHANGING HEADGEARS AT PLEASLEY COLLIERY."*

Mr. G. J. BINNS (Duffield) said that he would like to allude to the somewhat delicate question of cost. It was a subject which many engineers did not care to divulge, but it would be useful to know what was expended in connection with this exceedingly interesting and extremely well-described operation.

Mr. W. E. WALKER (Manners Colliery) said that they had had done very similar work. Their headstocks, built of wood, were 50 feet high and weighed fully 50 tons. The new headstocks were erected as close by the side of the old ones as possible; and taking advantage of the Miners' Demonstration Holiday, on Monday, July 14th, 1902, they started on the previous Friday night to dismantle the old headstocks and to push the others into position. The six legs of the new headstocks had been previously

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 348.

fixed on heavy rollers, resting upon old boiler-plates. On the Saturday morning, crabs were attached to the old headstocks which were then pulled bodily over and out of the way. The old headstocks were removed by 12 workmen, and all was cleared away by Saturday midnight. Work was resumed at 5 a.m. on Sunday; at 4 p.m. the new headstocks had been "pinched" into their proper position; and at 10 a.m. the headstocks had been dropped into the shoes placed ready for them—the men only worked for 6 hours on the Sunday. All day on Monday was spent in suspending the guide-rods, and completing the fittings, in order that everything should be ready for winding on Tuesday morning. As a matter of fact, the work was completed at 7 p.m. on Monday, and the ordinary men were run down at 8·30 p.m. The number of men employed never exceeded 12, and 6 of them were engaged all night on Sunday. The whole cost was £15 10s.

Mr. G. Spencer (Mapperley) said that since the Pleasley headgear had been fixed there had been two similar operations in the district:—The one described by Mr. Walker at Manners colliery; and the other at Mapperley colliery under his (Mr. Spencer's) charge.

The new headgear, at Mapperley colliery, constructed of pitchpine, was erected during the previous year in a field about 300 feet from the pit-top, where it awaited a favourable opportunity to be placed in position, without impeding the work of coal-turning. Such an opportunity did not occur until the present year, owing to regular trade and other circumstances. Advantage was therefore taken of the August Bank Holiday, which is observed by the miners, and takes place at a time of year when the days are long. It was originally intended to erect the headgear temporarily, so as to ensure the proper fitting of the parts, and to take it to pieces for re-erection close to the pit-top, and in a line parallel to the old one, which it was intended to replace, so that the operation of moving it into its permanent position would be comparatively a simple one. Consequently, no regard was paid to building it in the line which it was found that it would afterwards have to traverse, if moved as a whole. Considering, however, that the headgear was completed in every detail, and that the expense of taking it to pieces and of re-erecting it would be considerable, it was decided to adopt the bolder plan of moving

it as it was, and in this decision we were further encouraged by learning that the operations at Pleasley colliery had been entirely successful.

It was found, before moving the headgear towards the pit-top, that it was necessary to turn it round through an angle of more than 90 degrees. A temporary underframe, consisting of strong longitudinal and transverse timbers, having been secured by bolts to the base of the upright and back legs, for the purpose of moving it on the rollers, a strong wooden pack to take part of the weight was placed under the centre of gravity of the structure, as determined from the model, which happened to be under the middle transverse timber of the underframe. On this centre, the headgear was rotated by means of a hand-winch, until the front faced the line of traverse; and planks smeared with tub-grease were laid down, upon which the front and back timbers of the underframe would slide. The experiment was then tried of moving the structure forward on a double line of planks, 3 inches thick, by means of rollers, steel tubular pit-props, 5 inches in diameter, being employed. The planks proved capable of bearing the weight, and were used throughout in preference to balks, which had been specially ordered for the purpose. A week or two prior to the stoppage, the headgear was moved to the pit-top in the manner described (the road, in places, being ballasted and packed up owing to its unevenness) and finished by making a turn, nearly at right angles, to bring it into a position parallel to the old headgear. Two hand-winches, attached to two sets of pulley-blocks, were employed in traversing the headgear, and the time occupied was between 4 and 5 hours. A derrick-pole was then erected between the old and new head-gears, in a position convenient both for raising the new pulleys to the new headgear and for lowering the old pulleys to the ground. The new pulleys were placed upon their pedestals, temporarily secured; and additional transverse timbers were fixed on the under side of the frame, so as to enable the headgear to be rolled sideways over the pit-top, when the time arrived for this work to be done.

On Friday, August 1st, 1902, the pit ceased work at the usual time; and at 5 p.m., when all the men had been drawn out, the work of taking down the wire-conductors and lowering the old pulleys was commenced. By 9 p.m., both winding-ropes had

been drawn over the pulleys, the cage-props had been removed, a scaffold had been fixed over the pit, and one of the pulleys had been lowered to the ground. It may here be mentioned that work was only continued during daylight, and with the same staff of men throughout.

On Saturday morning, work was resumed at 4·30 a.m., and by 10·30 a.m. all arrangements were in readiness for pulling over the old headgear. By means of an old winding-rope attached to the top of the headgear, two locomotives were connected to it, and at a given signal both pulled together. The front and back legs had previously been sawn through, so as to ensure the structure falling in the required direction; and, in 10 seconds from the time of giving the signal, it fell to the ground across the railway exactly as desired. The rest of the day was spent in removing the débris, and in building the foundations (blue bricks set in cement) for the new headgear. By 6 p.m. the new headgear was traversed to its approximate position over the pit, and work ceased for the day.

Work was commenced at 6 a.m. on Sunday, and continued until 8 p.m. The headgear was set in its exact position by plumbing from the bed of the pulley-wheels to marks made on the scaffold. During this day all the conductors had been re-fixed to the new headgear, and one winding-rope had been taken over the pulley, thus making it possible to use the pit for lowering or raising men, if required.

On Monday, operations recommenced at 6 a.m.; and during the day the work was completed, and the tackle and timbers used in moving the structure removed; and at 8·30 p.m. all appliances were made ready for coal-turning on the following day.

The headgear at Mapperley colliery is not so large as that described by Mr. Longden, being only 41 feet high to the sills, and the weight moved would not exceed 45 tons, including the temporary underframe. But, judging from the facility with which the headgear was moved, he (Mr. Spencer) would not hesitate to move one of any dimensions or weight, it being simply a question of the proper application of the haulage-tackle.

Mr. S. A. Everett (Gedling) said that it was very desirable that operations, which did not come within the range of everyday colliery-procedure, should be placed upon record, as the informa-

tion was valuable in guiding others who might have similar work to do. Mr. G. A. Longden had given a brief description of the headgear which had been removed, but the value of his paper would be considerably enhanced if he would supply a few particulars of the design of the new headgear. Two very similar operations happened to have come within his own experience, in both of which a wooden headgear was supplanted by a steel structure. In one case, this was erected in the same relative position as that described by Mr. Longden, that is to say, in front of the old headgear; and it was then drawn backward into its place, after the wooden structure had been demolished by throwing the two sides outward. In the other case, an account of the very limited ground available for the erection of the new headgear, it had been erected at the side of the existing one, and the removal of the latter was attempted in a manner similar to that described by Mr. Longden. The back legs were secured, near their top, to the winding-rope, and the engine-brake was put hard down; 3 men were engaged in sawing through these legs at their junction with the main-legs; when, much to everyone's surprise, before the wood was quite severed, the weight of the back legs proved too much for the rope (owing to the awkward angle at which they were held) and, pressing upon the remainder of the structure, caused it to lurch bodily forward and fall upon the corrugated-iron roof of the screens, which, collapsing gradually, steadied its fall and, fortunately, prevented any of the men from being injured during their aerial flight. This incident showed that a few square inches of rotten wood (all that remained) was capable of performing the duties of the back legs; that the mere weight of these legs, as usually erected, produced in the headgear a forward thrust far greater than the backward one due to the pull of the ropes, which they were intended to counteract; and consequently, in most cases, that the conception of their function as struts was an exaggerated, if not a mistaken one. In both cases, the method of traversing the new headgear differed in detail from that referred to by Mr. Longden in his paper, and by the previous speakers. Each leg rested upon a strong four-wheeled bogie running on a carefully-prepared road of heavy rails, which directed the headgear into position; and this method seemed preferable to the use of rollers, as it was more expeditious and required less power. The whole operation

of changing the headgears, from the cessation to the resumption of winding, occupied a period of 80 hours. In illustration of the great variation in the designs of headgears, he might mention that the headgear at Pleasley colliery weighed 112 tons, while that referred to in the second case was 45 feet high and only weighed 12½ tons, although its load was probably greater, as it had to carry 8 wirerope conductors: it had now been in use for many years with satisfactory results.

DISCUSSION OF MR. W. E. GARFORTH'S PAPER ON "THE APPLICATION OF COAL-CUTTING MACHINES TO DEEP MINING."*

The PRESIDENT (Mr. G. Elmsley Coke) remarked that Mr. Garforth had gone into the question deeply and thoroughly, and he thought they would all agree that in longwall working the face should move quickly, and as far as possible in a straight line.

Mr. J. T. TODD (Blackwell) said that there were two or three questions to which he should like to refer, but not in the way of adverse criticism, as he fully recognized the good work that Mr. Garforth had done; and as he (Mr. Todd) happened to be the producer of 5 per cent. of the coal got by machinery in this country, the members would recognize that he did not object to the use of mechanical appliances.

He (Mr. Todd) would first refer to the height of the cut or holing being 5 inches. If they were working a seam 5 feet or 5½ feet thick, a drop of only 5 inches was not much for a cut 6 feet deep; and he should like to hear Mr. Garforth's experience with regard to the dropping of the coal in bulk, and as to the breakage of that coal when loaded into the trams. In a seam 5½ feet thick, he (Mr. Todd) found that there was considerable difficulty in breaking the coal after it came down. The coal dropped almost in a solid mass, and had to be broken before it could be filled into the trams. Mr. Garforth said, although he did not quote any figures, that there was a much larger quantity of slack made by hand-getting than by machine-getting. He (Mr. Todd) would like to know whether his experience was gained from the coal put

* *Trans. Inst. M.E.*, 1902, vol. xxiii., pages 312 and 346; and vol. xxiv., page 201.

over the screens, or whether it was gained from the actual production of coal in the mine. Because the coal was loaded by hand, or by fork or gripes, and the slack was supposed to be cast back into the gob: therefore it ought not to come out of the pit, and the true comparison should be made with the coal passed over the screens. Then with respect to the quantity of coal got, Mr. Garforth stated that he was able to produce from a short length of face a large quantity of coal. He (Mr. Todd) found that Mr. Garforth with 1,100 feet of coal-face, progressing at 16½ feet per week, was producing 2,500 tons per week. This represented an output of about 60 tons per stall per day, which was a larger quantity than any member present could produce out of any stall. He asked whether one or two shifts were worked, and how the roads were manipulated so as to obtain that quantity out of each stall.

In Appendix II., a comparison was made of the costs of working a seam, 6 feet thick, cut by hand, and another, 3½ feet thick, cut by machine; but he (Mr. Todd) did not find that the cost of working the plant was included. Nothing was allowed for maintenance or depreciation, or for cost of steam or engine-power or anything in connection with the production of the power necessary to effect the cutting.

Mr. Garforth referred the members to his paper on "The Comparative Advantages of Electricity, Steam and Compressed Air for Mining Purposes;"* and it would be very interesting if they could have some comparison as to the merits of coal-cutting machines worked by air and electricity, more especially as at the present time, a Departmental Commission was enquiring into the use of electricity in mines. He should also like Mr. Garforth to tell the members some of the difficulties accompanying coal-cutting, the breakdowns of machinery, and the best means of having them quickly repaired, the cost of breakages, and the weaknesses of coal-cutting by electricity. The members would then be able to compare the cost of getting coal by hand, or by air-driven machinery, or by machinery worked by electricity. Personally, he thought, from an experience based upon an output of 230,000 tons a year, that there was an absolute profit in using electric power. He was using both electricity and compressed

* *Minutes of Proceedings of the Institution of Civil Engineers*, 1899, vol. cxxxviii., page 436.

air, and for future developments he would erect an electrical plant. From figures, carefully taken out, allowing for depreciation, interest on plant, etc., coal-cutting by electric power undoubtedly left a balance on the right side. Labour-difficulties were minimized, and probably also an extra quantity of coal was worked, which they otherwise would not be able to produce.

The PRESIDENT asked whether Mr. Todd had had any experience of sparking from the wires near the face; and whether he would consider it safe to use electricity in a gassy mine.

Mr. J. T. TODD replied that he was not using electricity in a gassy mine, but he could see no reason why a motor should not be used in such a mine. There was great contention as to the risk, but there was a risk in working a mine under any conditions. It was desirable to control the power in the best way possible, and to reduce the risk to a minimum. If they were not allowed to use an electrical plant in a mine which could not be worked profitably without it, the mine would be closed.

Mr. J. H. W. LAVERICK (Pye Hill) said he understood that sparking could be overcome by the use of polyphase-current motors; and he asked whether any of the members had had experience with polyphase-current motors for driving coal-cutting machines.

Mr. HENRY DAVIS (Derby) said that three-phase motors had been applied to coal-cutters, and they had done a considerable amount of work with great success. Mr. Roslyn Holliday, of Acton Hall colliery, had communicated his experience with three-phase electric driving applied to coal-cutters, in a paper read before the British Society of Mining Students.* He found no difficulty in headings, as in such machines they started without load; but in longwall-cutting he had an arrangement whereby it was started light, and after five revolutions of the motor, it took up its load. He asked Mr. Todd whether he considered that there was any actual danger of firing gas at the commutator of direct-current generators, because this matter would certainly be discussed by the Departmental Committee on the use of electricity in mines, and there would be considerable opposition on the part

* *Journal of the British Society of Mining Students*, 1902, vol. xxiv., page 171.

of coal-owners to any rules by which the use of open commutators would be excluded.

The PRESIDENT asked whether the use of polyphase current avoided the danger of sparking.

Mr. HENRY DAVIS replied that there was always danger where there were live cables, but, as Mr. Todd remarked, the collieries would have to be closed if they were not allowed to work any dangerous machines in them.

Mr. J. T. TODD said that personally he did not think there was any danger at the motor. A coal-cutting motor was placed low down or on the ground, and a place must be full of gas before any risk would be incurred from sparking at the motor; and if the place contained a dangerous quantity of gas it should not be worked. He had printed rules, under which the surroundings of their machines were examined at intervals of not more than 30 minutes, and if the machines stopped more frequently, an examination took place then. He could not see that there was any possible danger, unless there was an outburst of gas and a sparking of the machine at the same time; and under the old conditions, they might have a broken lamp and an outburst of gas at the same time.

Mr. M. H. HABERSHON (Sheffield) said that he had had experience of machine-cutting to a depth of 5½ feet, and found that it was impossible to make the cut without taking out rather over 6 inches. He thought that the height of 5 inches, referred to by Mr. Todd, would refer possibly to a less depth of holing: and certainly with a depth of 6 feet the height of the holing would exceed 5 inches. With regard to the output of coal from the face he thought it would be found that, in the case mentioned by Mr. Garforth. the gateways were placed nearer together than was customary in this district, so that more men worked on a certain length of face than was usual in hand-work. He thought that it had been pretty well established, from an experience of some years, that they must not expect to obtain much saving in the actual cost of the holing; and that the economy resulted more from the increased percentage of large coal: in some tender seams, the use of machinery had enabled a much larger proportion of large coal to be got by cutting on end, and

these seams could not be worked on end without the aid of machinery; in other words, without machinery such seams could not be worked at a profit. The next question was as to the use of electricity compared with that of compressed air, and certainly where the floor was of a heaving nature, the expense of placing and maintaining air-pipes would be greater than the expense of cables. With the motors on the machines properly enclosed, he considered that the question of sparking from the commutator could be put entirely on one side. With a polyphase current, three cables were required, while only two were required with ordinary continuous current; and he had preferred to adopt the latter.

Mr. Isaac Hodges (Whitwood Collieries) said it was interesting to hear that Mr. Todd had adopted a set of rules, requiring the coal-cutters to be stopped every 30 minutes, in order that an examination might be made of the face. Mr. Todd had asked as to the difficulties met with in electric coal-cutting, but he thought that no one knew more about it than Mr. Todd, and he should like him to describe his difficulties. He could then compare notes with Mr. Garforth, and the information could not fail to benefit the members. He (Mr. Hodges) had found, with a holing 5 inches high and a depth of 5½ feet, that the coal came down in such large blocks that shots had to be fired to break up the coal ready for loading. That was not by any means desirable, and the only remedy was to make a higher cut, and in that case he was afraid that the cost would then almost equal the cost of hand-holing. In seams approaching a thickness of 4 feet, the difference in cost between machine and hand-holing did not exceed 1½d. per ton saving; but there was a considerable saving by the improved quality and character of the coal. He had two faces of coal (each 1,300 feet long) in the same seam, one worked by machine-holing and the other by hand-holing, so that it was quite easy to compare results, and he found that the large sample was very much increased and the small sample correspondingly decreased by the machine-holing; being worth 5d. to 6d. per ton more than hand-got coal. In thin seams the conditions were entirely different; and some seams could not be worked without coal-cutters. They were working seams down to 2 feet thick, where they had a price list for hand-got coal of 2s. 8d. per ton

(plus percentage) and they could not possibly have worked with profit at the present time without coal-cutters. Mr. Todd had spoken of the advantages of electricity over air from the point of view of cost. He (Mr. Hodges) was interested in this problem, but he was unable to make up his mind from the data so far available. Many collieries were fitted with old-fashioned air-compressors, and consequently did not obtain results which would otherwise be possible. He had recently considered a scheme for producing 2,000 horsepower by utilizing the waste-gases from coke-ovens, and he found that large gas-engines of 1,000 horsepower, coupled direct to air-compressors running at 150 to 160 revolutions per minute, having large clearance-spaces, gave results much better than they had been led to expect. In making a fair comparison, they must take the conditions of a modern polyphase electric plant, and a modern high-speed air-compressor. Mr. Garforth had told the members that the coal did not require to be broken up in some of his seams, and with regard to the difficulty of producing the output he believed that the gateways were about 120 feet apart, so that there would not be so many tons per gateway to deal with as Mr. Todd had calculated. In that part of Yorkshire, all the slack was sent out of the pit; therefore the proportion of slack was a question of screen-percentages, and not of pit-percentages.

The further discussion of the paper was adjourned.

DISCUSSION OF MR. M. H. HABERSHON'S PAPER ON "A JOINT COLLIERY RESCUE-STATION;"* AND MR. W. E. GARFORTH'S PAPER ON AN "EXPERIMENTAL GALLERY FOR TESTING LIFE-SAVING APPARATUS."†

Mr. M. H. HABERSHON said that three adjoining collieries in South Yorkshire, having agreed to establish for their own use a joint station, they naturally wished to obtain information from those who had had experience in connection with the matter. The subject had been discussed in several districts, and valuable

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 100; vol. xxii., page 195; and vol. xxiii., pages 134 and 164.

† *Ibid.*, 1901, vol. xxii., pages 169 and 192; vol. xxiii., pages 37 and 164; and vol. xxiv., page 175.

information had been brought forth thereby. The discussion had chiefly related to the apparatus itself and the utility of Mr. Garforth's experiments in his experimental chamber. The members who saw the experiments at Altofts colliery would remember that the apparatus used was of the Meyer helmet-type. One important result had been achieved, namely, the men lent themselves readily to the work of practice, and there was no reluctance to try what they could do. Points on which improvements were desirable were manifested. At the recent visit of members of the Midland Institute to the Shamrock Colliery in Westphalia, Mr. Meyer demonstrated the use of the Giersberg—a new apparatus, and two men wearing the apparatus remained in the practice-chamber for 1¾ hours, and did actual work in an atmosphere which had been made unbreathable. Mr. Meyer had abandoned the use of the helmet, as he had found, owing to the difficulties of seeing and hearing, that the helmet was objectionable. The Giersberg apparatus embodied several important improvements:—(1) Solid alkali was used in place of the liquid used in the other apparatus. It was found that the liquid in the mixing bag was liable to pass up the tubes into the mouth, and produce burning, and the use of solid alkali obviated this risk. (2) The oxygen was passed through an injector, before it mixed with the inspired air. This injector could be regulated to the actual needs of the individual wearing the apparatus, so that when put on and adjusted, he required to devote no further attention to this point. (3) A safety-valve provided for the escape of any excess of oxygen in the breathing-bag. (4) Each apparatus was fitted with a pressure-gauge, which, however, was not visible to the man using the apparatus. Mr. Meyer had laid down the rule that all rescue-work must be conducted by not less than five individuals. One man must be in charge, and he must do nothing beyond looking after the safety of the other four men; and he could see by the pressure-gauges the exact amount of oxygen present in each of the cylinders, and when he found any getting short he must order the retreat of the whole party. There was another matter which he (Mr. Habershon) thought must be insisted upon, and that was, that the men must not exceed their instructions. There had been on the Continent one or two cases where the pneumatophor had failed, not from any failure

of the apparatus, but owing to the men exceeding the instructions given to them. It was absolutely necessary that a number of men should be properly trained, and that a code of rules should be established, such as he had attempted to foreshadow in his paper. The Hibernia Company owned eight collieries, under the direction of Mr. Meyer, and they had no less than 170 men trained and capable of using the apparatus at a moment's notice. A supply of apparatus was stored at the various collieries, and if any work were required at a gob-fire, the men were encouraged to make use of the apparatus, so that they were constantly in training. We were certainly behind in this country in this matter, and he thought that mining-engineers and colliery-owners should no longer trust to luck as they had done, but ought to be in a position to utilize any apparatus of ascertained value in the case of a catastrophe. There had been a tendency to condemn the experiments at Altofts colliery, because the men suffered from severe headaches. In the case of a calamity such as had too often been experienced, there were many men who would come to the front and be willing to risk more than a severe headache if it were possible to save life. The joint rescue-station was now ready for occupation, they proposed to obtain five sets of the Giersberg type of apparatus with the view of training some of their deputies, or other suitable men, so that they would soon be doing something practical in what he believed to be a very important matter.

Mr. H. R. Hewitt (H.M. Inspector of Mines) said that he was present at Altofts colliery when these experiments were made, and he did not believe in minimizing the difficulties under which the men worked while passing along the gallery. From an interview with the men he found that the headache from which they suffered was severe, and the action of the pulse was greatly increased. He had come to the conclusion that the headache was due to a defect in the helmet, which allowed the men to inhale some of the dreadful atmosphere through which they passed. This being so, the experiments were useful in showing those defects, and in what direction improvements might be made. He was pleased to hear that the Giersberg apparatus was likely to supersede the Meyer helmet in that particular, and whatever apparatus and helmet were used, they must be

self-supporting for respiratory purposes and all outside atmosphere must be excluded. The atmosphere in the experiments at Altofts colliery was certainly an abominable one and well calculated to test any form of helmet. He (Mr. Hewitt) was in favour of two oxygen-cylinders being carried in preference to one only, even should that one be fitted with a sensitive gauge to show what volume of oxygen remained. Two completely-charged cylinders would give the men more confidence in the appliance. The thanks of the members were due to Mr. W. E. Garforth and to Mr. M. H. Habershon for the trouble that they had taken in this question, and he was glad to hear that a group of collieries in South Yorkshire had fitted up a station, from which he hoped they would have the benefit of their experience from time to time. He was afraid that nothing had been done in the Midland mines-inspection district, and he would like to see a colliery-owner taking the lead in this matter, although he hoped that the time would be far distant when its practical application might be required in some great calamity.

Mr. M. H. Habershon said that the pneumatophor of the Shamrock type had always been fitted with two oxygen-cylinders, so that one might be used in going to a point and the other in returning from that point; but he found, in conversation, that Mr. Meyer did not encourage that practice. The Giersberg apparatus had two oxygen-cylinders, but that was more a matter of convenience, and he would prefer to rely entirely on the man in charge, who, when he saw that the oxygen was being used, would order the retreat of the entire party. With the new apparatus, the rate of consumption of oxygen was constant, which had not been the case in the older type of apparatus. A man who got excited would use up more oxygen, but with the Giersberg apparatus, he could only consume it as fast as it was passed through the injector and the regulating-valve. He therefore thought that the objection as to the use of one cylinder lost some of its force.

The discussion was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 13TH, 1902.

SIR LINDSAY WOOD, BART., PRESIDENT, IN THE CHAIR.

THE LATE MR. G. F. BELL.

Mr. J. G. WEEKS said that, since the last meeting, they had lost by death, Mr. G. F. Bell, H.M. inspector of mines. The deceased gentleman was a member of the Council, who in his work amongst them had been recognized as a friend in every sense of the word. It was with very great regret that the members had heard of his death, and he moved that a vote of condolence be sent to Mrs. Bell expressing their regret at her husband's death, and conveying their sympathy with her and her family in their bereavement.

Mr. HENRY LAWRENCE seconded the vote of condolence.

The vote of condolence was unanimously adopted.

The Secretary read the Minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 29th and that day.

The following gentlemen were elected, having been previously nominated:—

HONORARY MEMBER—

MR. ROBERT MCLAREN, H.M. Inspector of Mines, 19, Morningside Park, Edinburgh.

MEMBERS—

MR. REGINALD BELL, Colliery Manager, The Equitable Coal Company, Limited, Jamooria Colliery, Raneegunge, Bengal, India.

MR. HERBERT WRIGHT CHAPMAN, Mining Engineer, Tower Hill, Middleton St. George, R.S.O., County Durham.

MR. BOURN RUSSELL CHICKEN, Mechanical Engineer, 17, Kenilworth Road, Newcastle-upon-Tyne.

MR. JOHN CURRY, Mechanical Engineer, The Lyons, Hetton-le-Hole, R.S.O., County Durham.

MR. WILLIAM DAVIES, Colliery Manager, Llanhilleth House, Llanhilleth, R.S.O., Monmouthshire.

MR. TELESFORO GARCIA, JUN., Engineer, Santa Teresa, 2, and P.O. Box 463, City of Mexico, Mexico.

MR. JOSEPH GREEN, Mining Contractor, Crag House, Ferryhill, County Durham.

MR. JONATHAN EDWARD HODGKIN, Electrical Engineer, Shelleys, Darlington.

MR. ROBERT HALL LONGBOTHAM, Engineer, Ings Foundry, Wakefield.

MR. NEIL McLELLAN, Mechanical Engineer, Idsley House, Spennymoor, County Durham.

MR. JOHN PETTIE MACTAGGART, Electrical Engineer, 21, Grainger Street West, Newcastle-upon-Tyne.

MR. THOMAS VENTRESS SIMPSON, Under-manager, Throckley Colliery, Newburn, R.S.O., Northumberland.

MR. ALFRED THOMPSON, Colliery Manager, Talbot House, Birtley, R.S.O., County Durham.

MR. ANTHONY WILSON, Mining Engineer, Thornthwaite, Keswick, Cumberland.

MR. JOHN WISHART YOUNGER, Mechanical Engineer, Washington, R.S.O., County Durham.

ASSOCIATE MEMBERS—

MR. PETER KIRK, 13, Mosley Street, Newcastle-upon-Tyne.

MR. SIDNEY REID, 26, Claremont Place, Newcastle-upon-Tyne.

MR. DAVID SAMUEL, Albert Street, Llanelly, South Wales.

MR. PETER SCHOLER, Royal School of Mines, South Kensington, London, S.W.

MR. ALFRED FRANCIS TOOVEY, 33, Westgate Road, Newcastle-upon-Tyne.

ASSOCIATES—

MR. JOHN CHIPCHASE, Foreman, 23, St. Helen's Terrace, Coxhoe, R.S.O., County Durham.

MR. PATRICK GALLAGHER, Master-shifter, 15, James Street, Newfield, Chester-le-Street, County Durham.

MR. ROBERT WILLIAM HALL, Mine-surveyor, 1, Railway Street, Murton Colliery, Sunderland.

MR. GEORGE WILLIAM HEDLEY, Surveyor, Deafhill Colliery, Trimdon Grange, R.S.O., County Durham.

MR. THOMAS PATTERSON, Colliery Engineer, East Hetton, Coxhoe, R.S.O., County Durham.

MR. WILLIAM PATTISON, Deputy-overman, 18, East Street, High Spen, Lintz Green, R.S.O., County Durham.

MR. JOHN WILLIAM ROBINSON, Under-manager, Callerton, Kenton, Newcastle-upon-Tyne.

MR. JOHN WILLIAM WILKINSON, Under-manager, Double Row, South Durham Colliery, Bishop Auckland.

STUDENTS—

MR. MATTHEW FORSTER CHEESMAN, Mining Student, Throckley Colliery, Newburn, R.S.O., Northumberland.

MR. ARTHUR ELLIOT, Mining Apprentice, 28, Burdon Terrace, Newcastle-upon-Tyne.

MR. JOHN GALLOWAY, Mining Student, Hebburn Colliery, Hebburn-upon-Tyne.

MR. JOHN BRIDGES BAILEY HAWKINS, Student, Murton Colliery, via Sunderland.

MR. JOSEPH TODD SWAN, Mining Student, Throckley Colliery, Newburn, R.S.O., Northumberland.

MR. GEORGE TEASDALE, JUN., Mining Student, Garden House, Pelton, Chester-le-Street, County Durham.

MR. THOMAS A. THIRLWELL, Mining Student, Wallsend Colliery, Newcastle upon-Tyne.

Mr. THOMAS DOUGLAS (Past-president) referred in terms of satisfaction to the success which had attended the recent celebrations in connection with the Jubilee of the Institute. The success of the proceedings on that occasion was very largely due to the great interest and trouble which the President had taken in the matter, and he begged to propose that a very hearty vote of thanks be accorded to him.

Mr. J. G. WEEKS (Past-president) seconded the resolution, which was very cordially adopted.

The PRESIDENT (Sir Lindsay Wood, Bart.), in acknowledging the vote of thanks, said that the success of the meeting was sufficient recompense to him for any trouble that he had taken.

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BELFAST, 1902.

The report of the proceedings of the Corresponding Societies Committee of the British Association for the Advancement of Science, and also that of Mr. J. H. Merivale, the delegate representing the Institute, were read as follows:—

BROOMHILL,
October 24th, 1902.

TO THE PRESIDENT AND COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENTLEMEN,

The meetings of delegates to the British Association for the Advancement of Science, appointed by local Societies, were held at the Queen's College on September 11th and 16th. I was present at both meetings, which were only moderately attended.

Erratic Blocks of England, Wales and Ireland.—The Committee, which has this matter in hand, would be very glad of assistance from any members

interested in geology, as the information that they have received in regard to erratics in the counties of Northumberland and Durham is very scanty. Mr. P. F. Kendall, the honorary secretary to the Committee, states that the information required is as follows:—

"The Committee desire local clubs to undertake the systematic examination of the areas covered by their operations. They should observe and record, mainly, rocks which by their nature can be seen to have been transported from a distance; and workers should not waste their energies in recording the occurrence of large blocks of local stones. The field in Northumberland and Durham is large, and comprizes almost virgin ground. Messrs. Lebour, Howse, Bulman, Dwerryhouse, and others have given some information, but only enough to whet our appetites. There are three pieces of evidence which the Committee and glacial geologists want to know:—(1) How far to the south and to the west the rocks from the Cheviot area descended into Northumberland and Durham; (2) how far south, west and east the Lake-district rocks were borne; and (3) how far inland such rocks as flints were borne from seawards. Observers should not limit their observations to large boulders, as many of the most significant erratic blocks occur solely as small stones, some not exceeding what might be called gravel. The attitude of boulders, that is to say of large boulders, when obviously *in situ*, is often of interest and importance, that is, the compass-bearing of their long axes."

Mr. Kendall will be pleased to render every assistance in his power to observers. He is willing to help by sending specimens of rocks of known origin, and also to identify, as far as he can, specimens submitted to him.

The subject is interesting, and, unlike many other investigations, it can be carried out at a small expense, as the equipment required only costs a few shillings. I take this opportunity of inviting the assistance of members, and I will be very glad to receive the names of those willing to help, or perhaps a committee might be formed to take up the matter.

The following papers and reports read at the meeting of the sections are of special interest to the members:—

- Presidential Address, by Prof. Dewar.
- Report of the Committee on "Earthquake Phenomena."
- Report of the Committee on the "Economic Effects of Factory Acts."
- Report of the Committee on the "Resistance of Road-vehicles to Traction."
- Report of the Committee on the "Teaching of Elementary Mathematics."
- Report of the Committee on the "Teaching of Science in Elementary Schools."
- Report of the Committee on the "Training of Chemists employed in English Chemical Industries."
- "Smokeless Combustion of Bituminous Fuels." By Mr. W. H. Booth.
- "Solignac Boiler." By Mr. W. H. Booth.
- "An Universal Language." By Sir Frederick Bramwell.
- "All Stations Express." By Mr. J. Brown.
- "An Elastic Wheel." By Mr. J. Brown.
- "Regulation of Wages in Developed Industries." By Mr. S. J. Chapman.
- "Undulations produced in a Road by the Use of Sledges." By Dr. Vaughan Cornish.
- "Water-power in Ireland." By Mr. F. T. Dick.
- "Science in Irish Secondary Schools." By Mr. T. P. Gill.
- "Direct-reducing Levelling-staff." By Mr. George Henderson

"Science Subjects in Schools." By Dr. Kimmins.
"The Corrosion of Copper by Sea-water." By Prof. Letts.
"World-shaking Earthquakes." By Prof. J. Milne.
"Steam-turbines." By Hon. C. A. Parsons.
"The Prevention of Smoke." By Mr. J. J. Rayworth.
"The Teaching of Elementary Mathematics." By Mr. A. W. Siddow.
"The Science of the Workshop." By Mr. William Taylor.

I am, Gentlemen,
Yours truly,
JOHN H. MERIVALE.

The PRESIDENT (Sir Lindsay Wood, Bart.), in moving a vote of thanks to Mr. Merivale for his report, said that he hoped the proposals with regard to the erratic blocks would be carried out by some of the members.

Mr. W. O. WOOD seconded the vote of thanks, which was cordially approved.

DISCUSSION OF PROF. H. LOUIS' PAPER ON THE "STANDARDIZATION OF SURVEYORS' CHAINS."*

Mr. S. J. POLLITZER (Sydney, New South Wales) wrote that, with all due respect to its author, the paper by Prof. Henry Louis on the "Standardization of Surveyors' Chains" came as a surprise; as he did not think that in 1902 there were people in Great Britain, one of the most civilized countries of the world, who still used the antediluvian chain. And it was respectively suggested to the learned professor, to the members, and to all other professional engineers that they should exert their influence to have the chain abolished entirely as obsolete, and to have it replaced by the more modern steel-tape.

Principal H. PALIN GURNEY read the following note on "The Crumlin Meteorite":—

* *Trans. Inst. M.E.*, 1902, vol. xxiii., pages 85 and 229.

THE CRUMLIN METEORITE.

By Principal H. PALIN GURNEY.

The writer is indebted for a cast of the Crumlin meteorite to the kindness of Mr. Lazarus Fletcher, F.R.S., the keeper of the Mineralogical Department, at the Natural History Museum, South Kensington. It represents all that has been found of a sky-stone, which fell at 10·30 a.m. on September 13th, 1902, at Crumlin, about 12 miles west of Belfast. A loud noise was heard at the time, which may be attributed to the breaking of the meteorite, and the detonation was observed at places 30 miles apart. The fragment weighs 9·34 pounds (4,237·5 grammes). It is 7½ inches long, 6½ inches wide, and 3½ inches thick. The edges are rounded, and five of its faces are nearly smooth, and show clearly the characteristic pittings. The remaining four or five surfaces are apparently due to fracture, and they exhibit distinct ridge-and-furrow markings. As Crumlin is only 3½ miles east of Lough Neagh, a lake extending over 13 miles by 7 miles, possibly the remaining pieces may be buried beneath its waters. The crack, represented on the model, was probably caused by impact on a larger stone in the earth, in which it buried itself to a depth of about 18 inches.

The meteorite is covered with the usual peculiar external layer. This crust or varnish is thinner on what are probably the surfaces produced by the breaking. It is mostly black or brown, the latter colour being possibly attributable to its contact with the soil, but on one part there is an iridescence, in which we may trace purple, pink and blue. On one of these surfaces, a flattish bronze-coloured nodule of troilite is distinctly visible.

The meteorite belongs to the variety known as "aerolites." It consists mainly of stony matter, but it contains sufficient nickel-iron to affect a magnetized needle. Its exact composition is at the present time the subject of investigation by Mr. L. Fletcher.

This fragment is larger than any meteorite which has reached

British soil since the fall at Wold Cottage, Scarborough, on December 13th, 1795, which weighed 44·34 pounds (20,111 grammes). It is the first sky-stone observed to fall in these islands since the Middlesborough meteorite, which was found on March 14th, 1881, and weighed only 3·52 pounds (1,594·4 grammes).

Principal H. Palin Gurney exhibited models of the Crumlin meteorite, together with an iron model prepared by Prof. A. S. Herschel to test the speed of fall of the original, and by which he had ascertained that the Middlesbrough meteorite struck the earth with a velocity of 412 feet per second.

The President (Sir Lindsay Wood, Bart.) moved a vote of thanks to Principal Gurney for his paper.

Mr. J. H. Merivale seconded the resolution, which was cordially approved.

Mr. A. H. Meysey-Thompson read the following paper on "Some of the Considerations affecting the Choice of Pumping Machinery," by Mr. H. Lupton and himself: —

SOME OF THE CONSIDERATIONS AFFECTING THE CHOICE OF PUMPING MACHINERY.

By A. H. MEYSEY-THOMPSON and H. LUPTON.

Economy of fuel at collieries is a question which is rapidly becoming important. The old objection to the introduction of economical pumping-plant, that the boilers only burnt unsaleable small coal, has been seldom heard of late years. The introduction of coal-cutting by machinery is tending to reduce the quantity of small coal; the manufacture of producer-gas on a large scale has opened out a lucrative market for inferior slack-coal; the growth of the briquette-fuel industry is eloquent testimony to the use that can be made of what was once considered almost valueless; and the washing of small coal and its conversion into coke have also greatly tended to reduce the supply of cheap boiler-fuel. It should also be remembered that each boiler saved represents a reduction of stokers' wages, of cost of insurance and of maintenance of boilers.

In a presidential address to The Institution of Mining Engineers, Mr. James S. Dixon stated that 7·39 per cent. of the output of a large group of Lanarkshire collieries was consumed at the pits, and he estimated that, at this rate, the consumption of the collieries of the United Kingdom was 16,186,852 tons.* He also expressed the opinion that a consumption of 10 pounds of fuel per indicated horsepower at collieries was very near the truth.†

Recently, Mr. A. M. Henshaw in a presidential address to the North Staffordshire Institute of Mining and Mechanical Engineers, stated that in their district they were wasting £106,800 a

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 372.

† *Ibid.*, page 373.

year, which might be saved by first-class steam-plant.* He said that actual tests at collieries had shown a consumption of 8·21 pounds of coal per horsepower; and it is worth noticing that, in the North Staffordshire district, the report of H.M. inspector of mines shows that out of 755 boilers no less than 285 are of the old egg-ended type.

At many collieries, the weight of coal raised is far less than that of water pumped, and as pits become deeper the horsepower necessary to raise the water to the surface must be proportionately increased.

Speaking generally, it may be said that the heaviest pumping in the past has been done by a steam-engine on the surface, working pumps placed underground by means of rods. The old single-cylindered beam-engine, generally of the Cornish type, remains to this day one of the most economical of steam-engines, when the steam-pressure does not exceed about 40 pounds per square inch. For higher pressures, where circumstances admit of its use, an excellent type of pumping-engine is the vertical, compound Cornish-cycle engine. An engine of this kind fitted with the Davey differential gear, supplied to the Basset tin-mines, Cornwall, has been working for several years, yielding a duty of 80,000,000 foot-pounds on 1 cwt. of slack.† This duty is not so high as that reached by some of the old single-cylindered Cornish engines of the past, but they only obtained it by cutting-off steam at a very early period in the stroke, and in order to carry the piston to the end it was necessary to give an excessive initial velocity to the pump-rods. The strain on the rods was so great that they rapidly broke down, and, in practice, the early cut-off was abandoned, as it proved most economical to work with a duty of about 50,000,000 foot-pounds. The second cylinder is introduced in order to obtain a large degree of expansion of the steam, without the necessity of cutting-off so early in the stroke. The excessive speed of the rods is thus obviated, and the pit-work is not subjected to undue strains.

The large output of a modern colliery demands so much shaft-accommodation that room can rarely be found for a beam at the

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 147.

† *Ibid.*, 1900, vol. xix., page 157.

pit-top; and as the Cornish engine is only single-acting, its capital cost is considerably higher than that of a double-acting engine of the same power. The foundations and engine-house are also costly. Hence, double-acting horizontal engines, taking steam on both sides of the piston, removed some way back from the shaft, and connected to quadrants or rockers, have been preferred; and these engines, being either triple-expansion or compound and condensing, enable high pressures of steam to be fully utilized.

The writers' firm are now building a triple-expansion engine for a colliery in Durham, capable of working with a steam-pressure of 200 pounds per square inch; and, as the steam will be cut off early in the high-pressure cylinder, the resultant economy will no doubt be considerable. An objection is sometimes raised to the use of horizontal cylinders of large diameter on the ground of excessive wear, but this has hardly been borne out by facts.

Through the kindness of Mr. Edmund Howl, engineer and general manager to the South Staffordshire Mines Drainage Commissioners, the authors are enabled to quote the results obtained during the last 13 years from two large overground engines with shaft-pumps. The particulars during this time have been most carefully tabulated, and as no other engines (excepting small winding-engines used occasionally when examining pit, and capstan-engines for shaft-work) took steam from the same boilers, the results are more accurate than can be obtained at many collieries.

(1) The larger of the two engines, called the Bradley engine, has high- and low-pressure steam-cylinders, 52 and 90 inches in diameter respectively, with a stroke of 10 feet; and it works two plunger-pumps, each 27 inches in diameter, also with a stroke of 10 feet. This engine was put to work in April, 1885, but separate cost-accounts were not kept until the year ending June 30th, 1890. In the 13 years from that time until June 30th, 1902, the engine had raised 11,686,000,000 gallons of water from a depth of 384 feet, equivalent to an average continuous night-and-day horsepower, in the water lifted, of 199, and to an average continuous piston-speed of 69 feet per minute. The average annual cost of working the Bradley pumping-engine during the whole period has been as follows: —

	Per Annum.	Per continuous Pump-horsepower per Annum.		
	£	£	s.	d.
Coal *	1,422	7	2	11
Labour	873	4	7	10
Stores, including oil and packing	99	0	10	0
Repairs to engine and pumps ...	110	0	11	1
Repairs to boilers	47	0	4	10
Totals ...	£2,551	£12	16	8

* The small slack coal used cost, on an average, 4s. 11½d. per ton of 23 cwts. delivered, and had an evaporative-capacity of 4½ pounds of water per 1 pound of coal.

(2) The smaller of the two engines, called the Moat engine, has high- and low-pressure cylinders, 44 and 76 inches in diameter respectively, with a stroke of 10 feet; and it works two ram-pumps, 19 inches in diameter, and below them a pair of bucket-pumps, 19½ inches in diameter, having a stroke of 10 feet, and with a total joint lift of 620 feet. This engine was put to work in 1885, but separate cost-accounts were not kept until the year ending June 30th, 1893. In the 10 years from that time up to June 30th, 1902, this engine has raised 7,391,525,000 gallons of water from a depth of 620 feet, equivalent to a continuous night-and-day horsepower of 264 in the water lifted and to an average continuous piston-speed of 115 feet per minute. The average cost of working the Moat pumping-engine during the whole period has been as follows:—

	Per Annum.	Per continuous Pump-horsepower per Annum.		
	£	£	s.	d.
Coal †	1,410	5	6	10
Labour	918	3	9	6
Stores, including oil and packing	98	0	7	5
Repairs to engine and pumps ...	150	0	11	5
Repairs to boilers	23	0	1	9
Totals ...	£2,599	£9	16	11

† The small slack coal used cost, on an average, 4s. 4½d. per ton of 23 cwts. delivered, and had an evaporative-capacity of 4½ pounds of water per 1 pound of coal.

It may be remarked that the cylinders and other parts of the Bradley and Moat pumping-engines are in excellent order, and that no important parts of either engines or pumps have at any time been replaced, with the exception of the pump clack-boxes—seven of which have been renewed.

As a standard of comparison it will be noted that taking the fuel-costs, half of the labour and stores, and the whole of the boiler-repairs, as belonging exclusively to the steam-plant; and, further, supposing that of the total power supplied to the

terminals of an electric motor 70 per cent. could be recovered in actual water lifted, current would have to be sold at 0·22d. per Board-of-Trade unit to be equivalent to the average of the above figures, as shewn in the following table: —

	Mean Cost of the Bradley and Moat Pumping-engines per continuous Pump-horsepower per Annum.	Cost of Pumping by Electric-current per continuous Pump-horsepower per Annum. At 1d. per Board-of-Trade Unit.	At 0·22d. per Board-of-Trade Unit.
	£ s. d.	£ s. d.	£ s. d.
Coal	6 2 4	—	—
Electric-current: Power	—	27 4 6	5 19 9
Do. Loss in mains, motor and pumps at 70 per cent. of combined efficiency	—	11 13 4	2 11 4
Labour	3 17 4	1 18 8*	1 18 8*
Stores, including oil and packing ...	0 8 6	0 4 3*	0 4 3*
Repairs to engines and pumps ...	0 11 3	0 5 7*	0 5 7*
Repairs to boilers	0 3 0	—	—
Totals	£11 2 5	£41 6 4	£10 19 7

* One half of the mean cost at the Bradley and Moat pumping-engines has been taken as belonging to the pumps.

In the case of pumps of large diameter, forcing against a heavy pressure, the writers have found that the old-fashioned practice of using large single valves is undesirable. When a large pump is provided with only one suction-valve and one delivery-valve very heavy shocks are often caused by the trigging-up of either valve through a wooden gag or other cause. In order to avoid this difficulty, multiple valves of small diameter have been substituted with beneficial results for one large valve. Several small valves in one large valve-box were found, however, to present difficulties when pumping a large quantity of water against a heavy head. The flanges of the valve-box must be made enormously thick, even more so than the rest of the casting. Consequently, unequal strains are set up in cooling after casting; and the box is weak, as a structure, from this cause, as well as from the fact that in large masses of metal, cavities are apt to form under the skin in casting, and are exceedingly hard to discover. Another disadvantage of grouping a number of small valves in one large box is that it is necessary to break a large joint and remove a heavy lid in order to examine or repair any of the valves.

Of late years, the writers' firm have adopted a standard pattern of valve-box, 6 inches in diameter—the number being varied

according to the size of the pumps. Being comparatively small, they are less liable to undue strains in cooling after casting, and it is much more likely that each of these small boxes will be thoroughly sound than one large one. As these valve-boxes are made exactly alike to an accurate standard, a spare box can be kept, to be substituted for any one requiring repair. This operation can be speedily carried out by one man, and the damaged valve sent to the surface for repair in its valve-box. The pumps alone stand in the pit; the valve-boxes are placed in a recess, where they are easily attended to without interruption to the work in the pit; and the workman is also free from the risk of anything falling down the shaft on to him.

The engine is placed close to the boilers, so that it receives perfectly dry steam and can be kept under the constant superintendence of the management. If desired, the engine may be placed just below the surface, leaving the whole of the pit-top free for the operations of the mine.

In heavy pumping with long rods, it is desirable to have as few reciprocations as possible. The rods should start slowly from rest, accelerating in velocity as the stroke proceeds. The momentum, thus obtained, stores up energy, which is expended during the latter part of the stroke, and allows steam to be cut-off early, with a resultant economy of fuel. A pause between the strokes enables the valves to close quietly before the return stroke, and the fewer the reciprocations the less is the wear-and-tear of the valves. Bearing these facts in mind, it is evident that the longer the stroke, within reasonable limits, the better; and the writers are of opinion that the direct-acting engine without a fly-wheel is the most suitable for pumping. It is difficult to run a fly-wheel engine satisfactorily, and impossible to work it expansively at a slow speed. No pause is possible between the strokes; and in the event of a spear-rod breaking, a pipe bursting, or of a valve failing to act and suddenly relieving the engine of its load, the strain put on the fly-wheel is apt to cause a serious accident. Cases have occurred under such circumstances of fly-wheels flying into fragments, which were thrown to considerable distances. It is also much more costly to build a long stroke fly-wheel engine than a direct-acting one.

Where low first cost is essential, an underground direct-acting steam-engine is no doubt the cheapest to instal; but as

regards economy in working, it is at a great disadvantage. The steam has to be carried down the pit in pipes which can with difficulty be kept properly clothed, especially in wet shafts; it condenses in the pipes, and even if carefully drained, generally arrives at the engine in a more or less wet condition. In a direct-acting engine of this class, little or no cut-off is practicable, and the ordinary single cylinder or duplex steam-pump is a notoriously extravagant consumer of steam.

A certain degree of economy can be obtained by adopting compound or triple-expansion engines, but their best results compare unfavourably with those of the overground type. The engine is often placed in an out-of-the-way corner, seldom visited by the management, and the costs of installation and repairs are higher than when erected aboveground. Carrying steam underground frequently damages the roof, and an inrush of water may drown the engine.* A point in favour of underground engines is the height to which they can force water in one lift.

At the Chamber colliery, Oldham, a compound condensing underground engine forces 100 gallons of water a minute a vertical height of 1,341 feet in one lift. Mr. W. W. Millington records the results of a trial made by him, there being 59 indicated horsepower and 50 horsepower in the water pumped, giving a mechanical efficiency of 84 per cent. The consumption of coal was 5·76 pounds per pump horsepower per hour.†

Where water has to be raised from dip-workings, hydraulic engines have been largely used, taking their driving water from the main column of the pumps in the shaft, and returning it along with the water pumped into the main sump. It is a very convenient system if the hydraulic engine can be placed reasonably near to the main sump, and if the main pumping-engine can be run a little faster to make up for the driving water supplied to the hydraulic engine. Hydraulic engines being of simple construction, can be left to themselves, are quite safe, and require little attention and few repairs, besides being cheap in first cost;

* One of the writers had occasion to visit a silver-mine in Mexico, where an underground Chicago engine was within a few days of being started; the water gained on the existing pumps and drowned them out, and they were only extracted, after an interval of a year, by an overground engine from Great Britain.

† *The Colliery Manager and Journal of Mining Engineering*, 1893, vol. ix., page 62.

and even when buried in water, they can be worked. In order to avoid shocks, it is important that the flow of power or driving water should not be interrupted; and the duplex is therefore preferable to the old single-cylinder type of engine. The great uniformity of flow, thus obtained, enables a smaller diameter of pipe to be used both for the power- and delivery-water. Where the hydraulic engine is placed, say, 2,500 feet from the main sump, the cost of power-pipes becomes a formidable item, and the friction of the water passing through them reduces the pressure, and consequently a larger quantity of water has to be used. In such cases, or where there is no main pumping-engine from whose rising column power-water can be drawn, the difficulty can be overcome by providing a steam-engine on the surface supplying water at, say, a pressure of 1,000 pounds per square inch and delivering it to the hydraulic engine placed in the mine. This method gives an efficiency of about 55 per cent.

In Westphalia, at mines from 1,500 to 2,000 feet below the surface, it was decided that rods were impracticable, owing to their great length; electricity was inadmissible, as giving too low an efficiency; and hydraulic pumping, by means of a steam-engine on the surface and hydraulic engines belowground, has been adopted in many cases. The water at the surface had a pressure of nearly 2 tons per square inch, and as much as 1,000 horsepower was thus transmitted. By adopting such a great pressure of the driving or power-water, the diameter of the pipe was kept small, and though practical difficulties due to the high pressure of the water were encountered, they were gradually overcome, and the system, when inspected by the authors last year, was working satisfactorily. A guaranteed efficiency of over 60 per cent. was obtained, but the first-cost of the plant was considerably higher per horsepower than that generally in use in this country, where the mines, as a rule, are not so deep, and cheaper systems can be adopted.

In the writers' experience, where circumstances allow of it, the method of pumping by rods actuated by a compound or triple-expansion engine on the surface, and when required to do so, also driving hydraulic pumps for draining dip-workings, is the most economical for heavy pumping, both as regards consumption of fuel and of repairs.

Electricity, as a means of transmitting power for pumping

purposes, has come into use of late years, and seems destined to play a larger part in the future. The lightness and portability of the cable as well as the small loss of power in conveying the current to a distance, are important points in its favour. A danger attendant on the employment of electricity is the liability to explosion, not only through the sparking of the dynamo, but also from the fact that an accident to the cable by a fall of roof or other cause may produce violent sparking.

Considering the great number of companies now commencing to supply electrical power on a large scale in this country, it seems probable that many collieries, especially the smaller ones, will be able to buy electric current cheaper than they can generate it for themselves. A mine-owner will do well to provide himself with a pump, which can do the whole of the work in a portion of the 24 hours; and if he can undertake not to use the current during the few hours that the maximum demand lasts, he will be in a good position to buy it at a low rate. Most of the electrically-driven pumps in this country are actuated by a motor running at a high speed, geared down to give the pumps a velocity of little more than 40 revolutions a minute. But gearing is noisy, takes up space, and absorbs a considerable amount of power in friction; and a preferable plan would be to drive the pumps direct by a motor, running at, say, 100 revolutions per minute. In order to run pumps at this speed, it is necessary to provide ample water-way and a consequent small lift to the valves.

A disadvantage at present attendant on electric pumping-plant is its low efficiency. At a recent installation in the North of England, it appears that the consumption of coal per pump-horsepower per hour was 7·6 pounds, and the equivalent duty amounted to 29,000,000 foot-pounds. Mr. James S. Dixon recently stated that his compound condensing-engine, driving a dynamo, consumed 3·34 pounds of fuel per indicated horsepower per hour.* Reckoning the electric efficiency at 50 per cent., including the pump-gearing but exclusive of the pumps, and the efficiency of the pumps at 90 per cent., to obtain 1 actual or pump-horsepower, there is a combined efficiency of 45 per cent. or 7·4 pounds of coal per pump-horsepower per hour consumed by Mr. Dixon's engine.

Another disadvantage attendant on electric pumping is the

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 373.

liability to get out of order. In an address to the Engine, Boiler and Employers' Liability Insurance Company, Limited, the Chairman (Mr. R. B. Longridge) stated that "one out of every nine [electrical] machines insured by the company had broken down during the past year," and that "even where trained electricians were in attendance, numerous breakdowns had occurred through lack of attention to cleanliness, which is so essential to the safety of electric machines."* If electrically-driven machines aboveground give so much trouble, it is hardly to be expected that the attention and cleanliness required by Mr. Longridge will be forthcoming to a greater degree at the bottom of a pit. Electrically-driven pumps are also at a disadvantage, compared with those driven by rods, in being unable to work under water. At the Yarlside mine, North Lancashire, two ram-pumps, 20 inches in diameter and 10 feet stroke, continued working at the rate of 8 strokes per minute for a month while submerged in water to a depth of 90 feet.† They were actuated by an overground engine with quadrants, and raised the water from a depth of 435 feet to the surface.

For pumping small quantities of water at points a long distance from the source of power, electricity is sometimes the only satisfactory way of transmitting the power; but, where great depths and large quantities of water have to be pumped, the greater efficiency of the hydraulic system, using water at a high pressure, will probably cause it to be preferred despite the somewhat heavy capital outlay.

As already mentioned, underground steam-engines have little to recommend them, except cheapness in first cost; their foundations are liable to be disturbed by movements of the floor, while the cost of running and of repairs are higher than is the case with aboveground engines. When saving of coal becomes important, no doubt rotative engines will supplant the use of direct-acting engines placed underground. The use of a fly-wheel is there a distinct advantage. The momentum of the rods, which enables an aboveground engine to cut off early in the stroke, is replaced in an underground engine by the fly-wheel, which stores up sufficient energy to allow of an equally high grade of expansion, with a resultant economy of fuel.

* *The Engineer*, 1902, vol. xciii., page 208.

† *Trans. Inst. M.E.*, 1899, vol. xvii., page 303.

The direct-acting underground engine is, however, frequently adopted as a stand-by to other and more economical pumping-engines. Running as it then does, during a limited period, the extra cost of fuel is not an important item, and may be counterbalanced by the saving in interest on the capital outlay. A rotative engine, of the same power, would cost more, and owing to the greater space occupied, would be more expensive to instal; consequently, in order to decide upon the preferable type, it becomes necessary to consider the number of hours that each will be required to run.

It is to be regretted that some system of measuring fuel, analogous to the old Cornish duty in millions of foot-pounds, is not more largely adopted; but that system had its disadvantages, because it involved the efficiency of the boiler in addition to that of the steam-engine. A preferable plan would be to compare the weight of steam used by the steam-engine with the actual foot-pounds of work done in water raised by the pumps, commonly expressed as pump-horsepower. The ratio, thus obtained, affords a means of comparing different systems and it is in this sense that the term " efficiency " might be advantageously employed.

In conclusion, it may be said that each system has its disadvantages, and that every proposed installation must be studied on its merits. In order to facilitate a decision as to the best type of pumping-engine to be adopted, the writers have endeavoured to state the chief points relating to each system which have come under their notice; and in submitting them to the members they hope that the paper may be productive of an exchange of opinion on the comparative merits of different kinds of pumping machinery, more especially as regards cost of repairs and maintenance as well as the general convenience of the mine. These are matters which can only be thoroughly understood by those who are using the machinery, and consequently know " where the shoe pinches," an experience compared to which that of the maker of the machinery can at best be imperfect and second-hand.

The North of England has always been a pioneer of progress in mechanical invention, and its able practical sons are to be found directing mining operations in all parts of the world. Their experience gives to a discussion of this kind an importance which it is hard to overrate.

To illustrate Messrs A. H. Meysey-Thompson and H. Lupton's Paper on "Some of the Considerations affecting the Choice of Pumping Machinery."

DUTIES OF DIFFERENT SYSTEMS OF PUMPING WATER EXPRESSED IN MILLIONS OF FOOT-POUNDS OF WORK PER 1 CWT. OF COAL BURNT.

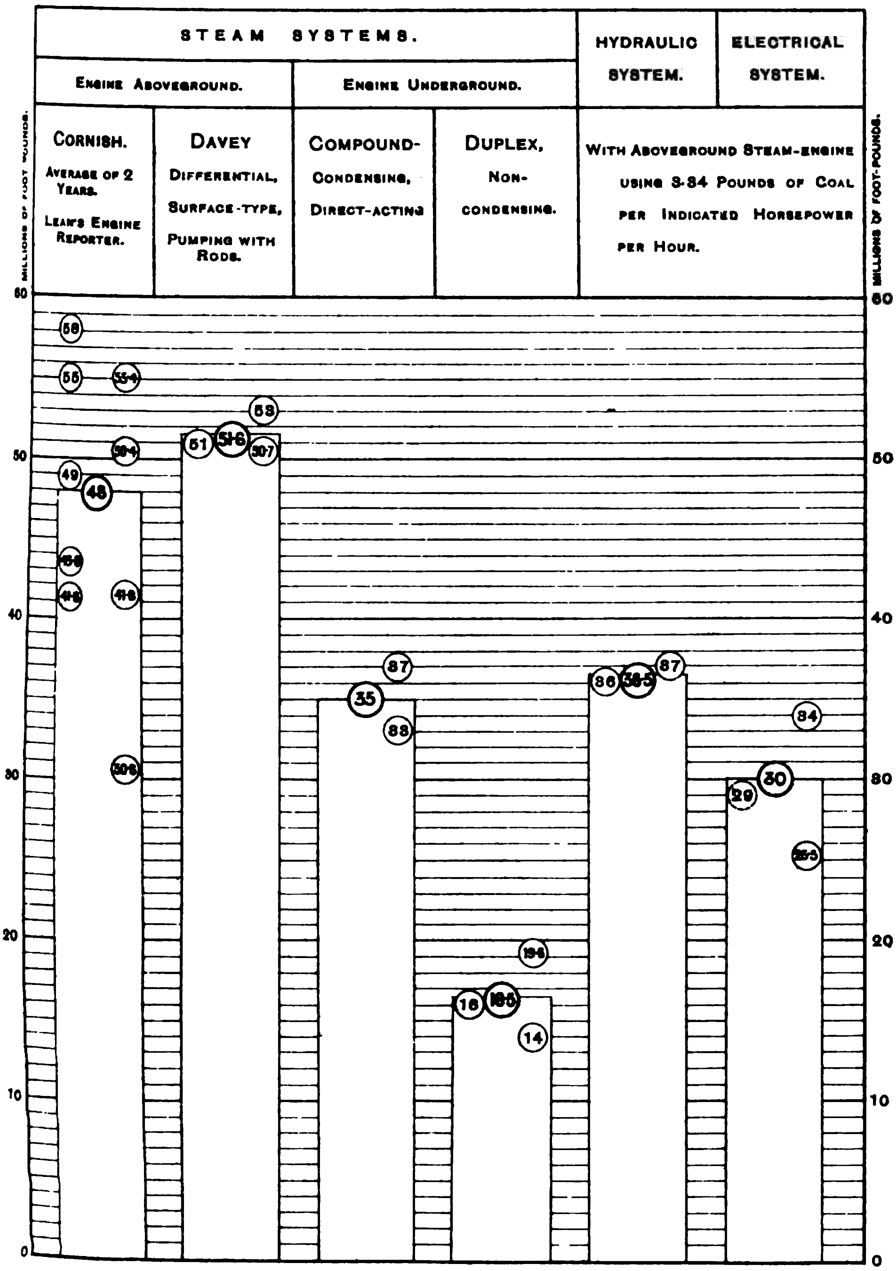


Plate VI. shews the duties of different systems of pumping water, expressed in millions of foot-pounds of work per 1 hundredweight of coal burnt. The light figures are taken from plants under ordinary working conditions, and the dark figures are the average duties of the different systems of pumping.

Mr. Henry Lawrence (Newcastle-upon-Tyne) asked what class of boilers were used at the Bradley and Moat engines, and whether there was anything to account for the large difference between the cost of repairs of the respective boiler-plants—the costs at Bradley being stated to be 4s. 10d. and at Moat to be only 1s. 9d. per continuous pump-horsepower per annum. In his opinion the most economical way of pumping water from great depths, was to have a series of small pumps delivering round the circle of the crank, or what would be the crank. He differed from the opinion expressed by the writers in the beginning of the paper as to the use of a flywheel, but they afterwards stated that under certain conditions a flywheel attached to a pumping-engine placed underground was a source of economy, enabling them to cut off and to work the engine expansively, and he accepted the latter as the correct view.

Prof. Henry Louis (Durham College of Science) said that he did not think that the authors had treated quite fairly the application of electric driving to pumping machinery; he did not believe that any great danger could arise from the dynamo or leads seeing that it was not customary to place a pumping-engine in the return-airway. In the usual position it might be considered fairly safe, and there would be little danger from sparking. He was convinced that much higher efficiencies had been repeatedly recorded for electrical machinery than those given in the paper, and the writers did not refer to the more modern type of pumps driven electrically. The Riedler express pump had been introduced lately, with mechanically-governed valves, which could be worked at a high speed, against fairly high lifts; and he believed that high efficiencies had been recorded for this pump. Several electrical plants claimed an efficiency of 60 per cent. or over. It was obvious that at a colliery having a lengthy range of coke-ovens, the waste-gases could be utilized for the generation of electricity, which could be economically applied in driving a pumping-plant, in which case a much lower

efficiency could be admitted than would be the case if they had to use coal; and the convenience of carrying electricity to a considerable distance was a factor that should not be overlooked. If danger from sparking at the commutator did exist, they could always fall back upon the triphase system. So far as his (Prof. Louis') limited experience went, he was not particularly in favour of this system, because if anything happened, and it was necessary to stop the pumps, one had to run off the water from the rising main before restarting the pumps, although he understood that a means had been devised for overcoming this difficulty.

Mr. T. Y. Greener (Crook) said that, having regard to the fact that electricity at the present moment was being largely utilized for power-purposes, he did not think that any statement should be allowed to go forth uncontradicted that its application underground was unsafe. He asked the authors, whether the statement that among the dangers arising from the use of electricity an explosion might be caused by sparking, was merely an opinion or whether it was based upon actual knowledge, as he had heard the point frequently denied.

Mr. J. C. B. Hendy (Etherley) said that he had had some experience with hydraulic pumps, and for the particular conditions which prevailed at the Etherley collieries the hydraulic pump had certainly proved successful. He was not able to state the efficiency, as the boilers were heated by the waste-gases from the coke-ovens. A Hathorn-Davey hydraulic pump had been working for about three years, placed about 1,400 feet from the shaft-bottom; it was pumping from various distances, from three different points in the dips; and, since it had been erected, he did not think that it had cost more than £1 or £2 per year for repairs. This was a case where the conditions were suitable for the use of hydraulic pumps; but if they had to place pumps at a considerable distance inbye, he thought that nothing could equal the efficiency of electricity. In the case of another hydraulic pump, there was a sudden inrush of water, which drowned out the workings; but the hydraulic pump worked for seven days under water and eventually it overcame the feeder and removed the water. This was one of the especial advantages attending the use of an hydraulic pump, which, if kept in order, would pump water, even when completely immersed.

Mr. F. R. Simpson (Ryton) said that he had employed an hydraulic pump when working to the dip in a heavily-watered colliery: it was situated 1,800 feet from the shaft-bottom, and had worked in a very satisfactory manner.

Mr. J. K. Guthrie (Preston Colliery) said that he had had an opportunity of seeing a Riedler pump at the Cramlington collieries, and it seemed to work in a highly satisfactory manner. It had only two valves of large area (one suction-valve and one delivery-valve). Indicator-cards had been taken, which showed great efficiency, and there was no "slip" or "hammer."

Mr. T. E. Forster (Newcastle-upon-Tyne) asked the authors to give further particulars of the installation of the electric pumping-plant in the North of England which gave the results quoted in their paper. Underground pumping could be divided into two heads, namely, shaft pumping and inbye pumping, and one method might be very good for one case, while another was the best for the other case. He thought that the use of electricity for underground pumping was very handy, and that it was probably as cheap as any other method. For pumping heavy feeders he was bound to agree that pumping-engines on the surface were generally the most economical, with possibly underground engines as a stand-by. In some pits, there was not much water, and where they could erect an underground electric pump, working in conjunction with dynamos and haulage and inbye pumping-plants, it might be, even supposing the efficiency to be little less, that it would prove the cheaper system. The idea that because a motor would spark it would therefore fire gas had not been proved, and the only experiments of which he had heard had pointed to the opposite conclusion. It was a point not yet satisfactorily settled, and it was very desirable that they should receive exact information upon the question.

Mr. C. W. Martin (Newbottle Collieries) wrote that the first note struck by the writers of the paper was a correct one. The day had gone by for the question of fuel-economy, even at collieries, to be regarded as of small importance. It was of ever-increasing importance, and it was this fact which made even first cost a secondary consideration. The authors had shown

wisdom in the choice of a title for their paper. It was one thing to lay out pumping-plant for an entirely new colliery, but it was quite another thing to instal suitable pumping-plant at an old colliery, and one must be content with what seemed best, all things being considered.

He (Mr. Martin) was inclined to disagree with the statement that underground direct-acting steam-engines had little to recommend them except low first cost. For depths of 1,200 or 1,400 feet, where the pumping must be done in the coal-drawing shaft, and steam was already conveyed down the mine for other purposes, perhaps the most satisfactory pump that could be installed was of the direct-acting compound type. It had few wearing surfaces and consequently cost little for stores, very little in the way of repairs, and required a minimum amount of attention. Where there was any movement of the floor, the direct-acting type had a distinct advantage over the rotative engine.

There were serious objections to placing heavy pumping sets in a working-shaft. In laying out a pumping-shaft at a new colliery or a central pumping-plant for a group of collieries, down to, say, 1,200 feet deep, undoubtedly the wisest plan was that of pumping by means of rods driven by a steam-engine placed close to the source of heat, and running on a high grade of expansion, and always taking the precaution of placing lifting-sets in the pit-bottom. A direct-acting condensing engine, with a long stroke and steam-jacketted cylinders, would probably give the best results.

The objection raised to the use of single clacks, with multiple beats, was not very obvious, as they worked well, and cost very little for up-keep. The danger arising from shocks could be readily averted by the use of relief-valves.

For dealing with large quantities of water from depths of 1,500 to 3,000 feet, the hydraulic system mentioned in the paper had much to recommend it. The engine on the surface could be made an economical engine, and the hydraulic motor in the mine was also highly efficient. But with this system of pumping, no fewer than four ranges of pipes were necessary, namely:—Rising main, power-pipe, return-pipe and air-pressure pipe, but as these were small in diameter, they could be easily fixed in a working-shaft. The cost of this plant must of necessity

be high when the enormous pressures were considered (up to 3,000 pounds per square inch) and they could only be satisfactorily controlled by a liberal use of cast steel in the manufacture of the plant.

The writers of the paper had done well in calling attention to the need of having some uniform method of expressing pump-efficiencies. German engineers, for instance, made statements of extraordinary efficiencies in setting forth the merits of their pumps, but on enquiry the basis of calculation was found not to be the same as that used in this country.

Mr. J. J. Prest (Castle Eden) wrote that the authors were no doubt correct in advocating the more general use of direct-acting triple-expansion condensing pumping-engines as a permanent installation for dealing with large volumes of water from shafts of a depth of, say, 1,000 feet. The only serious objection to the more general adoption of this class of pumping-machinery is the amount of room taken up in the shaft by the pump-work together with the first cost of the installation. The problem to be solved in all cases is, whether the economy capable of being effected by the adoption of this class of pumping-engine is sufficient to return ample interest on the increased capital-expenditure required, as compared with an underground steam pumping-engine, all other things being equal. There can be no doubt that at least one-half of the fuel is wasted, by condensation, in steam-pipes conveying steam to many large underground pumping-engines. If the value of this fuel so wasted amounts to, say, £500 per annum in the case of a steam underground pump, and the increased cost of a high-class pumping-engine plant should amount to £3,000 only when compared with the underground pumping-engine, then there is sufficient margin to warrant the increased expenditure being incurred. In many cases, however, the economy resulting from the increased capital-expenditure necessary to replace existing plants would not warrant the conversion. For unwatering sinking shafts, the class of pumping-engines advocated by the authors was not suitable.

Mr. A. H. Meysey-Thompson (Leeds), replying to the discussion, said that none of the results given in the paper were their own figures. Lancashire boilers were used at both the

Bradley and Moat pumping-engines, and it was purely accidental that the cost of repairs at one place had been 4s. 10d. and at the other only 1s. 9d. per horsepower per annum. Possibly the feed-water had something to do with it, as the boilers were placed several miles apart. He believed that the Riedler pump, with mechanically worked valves, was not largely in use in this country, although one had been working at the Powell Duffryn collieries for many years. The present electric pump was geared, and gearing was noisy and wasted a lot of power as friction. If a pump could be run at 100 revolutions per minute, with the motor directly connected, it would prove a most useful form of machine. He could not give any definite opinion with regard to the sparking of electric motors: he was told by mining-engineers that violent sparking was dangerous, and when a cable broke there was danger of sparking.

Mr. H. Lupton (Leeds) stated that the electric plant referred to in the paper from which the figures were quoted, was driven by a compound engine, with cylinders 18 and 30 inches respectively in diameter by 40 inches stroke, running at 80 revolutions per minute and supplied with steam at a pressure of 100 pounds per square inch. It worked two sets of three-throw pumps in the shaft; the actual horsepower in water lifted by the pumps was 121, and the duty of the whole plant was 29,000,000 foot-pounds. The average duty of the engines referred to in the paper was 51,000,000 foot-pounds for steam and 30,000,000 for electricity, where both plants were giving their ordinary duty.

Mr. J. G. Weeks (Bedlington) remarked that the use of compressed air had been totally ignored throughout the discussion, but there were circumstances under which its use was highly advantageous. He moved that a vote of thanks be accorded to the writers for their interesting paper.

Mr. J. H. Merivale seconded the resolution, which was cordially approved.

The further discussion was adjourned.

Mr. Mark Ford read the following paper on "Sinking by the Freezing Method at Washington, County Durham":—

SINKING BY THE FREEZING METHOD AT WASHINGTON, COUNTY DURHAM.

By MARK FORD.

1. *Introduction.*—The great interest shown by the members in the operation at Washington, and the novelty of the method, probably adopted for the first time in Great Britain, has induced the writer to give the following detailed description of sinking through alluvial deposits to the stone-head at the Glebe Winning belonging to the Washington Coal Company, Limited.

The company, having acquired the royalties of the Oxclose and Glebe collieries, abandoned forty years ago, decided to sink two shafts, 14 feet and 12 feet in diameter respectively, in a position such as to secure the most economical arrangement of haulage, shaft-bottom and surface-plant in preference to re-opening the old shafts.

2. *Nature of Ground.*—After trial-borings had been made over a certain area, it was found that the shafts would be sunk through drift, consisting of sand and boulder-clay. At the site adopted for the shafts, the following section was proved:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	3	1	3
2	Yellow sand: dry...	34	6	35	9
3	Grey sand: wet	41	3	77	0
4	Blue clay	0	1	77	1
5	Grey sand, with a gravel-bed: damp ..	2	4	79	5
6	Clay, with boulders: dry	12	11	92	4
7	Loamy clay: dry	5	2	97	6
8	Stiff clay, with boulders: dry	9	7	107	1
9	Yellow freestone	13	0	120	1

3. *Method of Sinking.*—The thickness of the sand-bed, the treacherous character of the quicksand, and the possibility of damaging the foundations of engines, boilers and other erections in the vicinity of the shafts, led, after careful consideration,

to negotiations with Messrs. Gebhardt & Koenig, Nordhausen, Germany, who undertook to freeze two shafts to the stone-head. This method offered almost a certainty of success, a dry shaft to sink, and no water or sand to pump to the surface.

4. *Preparatory Work.*—The usual headgear and pulley were erected, and a permanent hauling-engine was so placed that both shafts would be served by it during the sinking (Fig. 5). This engine has two cylinders, each 18 inches in diameter by 36 inches stroke, and is geared as 2 to 1, to two drums, 6 feet in diameter. A locked-coil wire-rope is used for winding.

Fig. 5.—Washington Colliery: Glebe Shafts.

The first and winding shaft will have a finished diameter of 14 feet. Its diameter to a depth of 24 feet was 24 feet, the sides being secured by ordinary wooden cribs, 6 inches square, placed 3 feet apart, and short backing deals were placed behind the cribs.

At 16 feet from the surface, a scaffold was erected, and on this scaffold, the holes in which the freezing-tubes, 22 in number, had to be placed, were marked off (Figs. 1 and 2, Plate VII.). This was done by drawing a circle on the scaffold having a radius of 10½ feet, and the circumference of this circle was divided into 22 equal parts, giving the centre of each bore-hole.

Boring-tubes were forced down to form the holes through

the sand. These tubes were 6 inches in diameter and 6 feet long, fitted with screwed flush-joints, the lower length having a sharp end. The sand-pump was occasionally put in, and by turning the tubes with the grips, they gradually sank until the gravel was reached; and then screw-jacks were used to force the tubes into the clay.

When the boring-tubes reached the clay, boring was continued by means of a chisel working inside the tubes, making holes $5\frac{1}{4}$ inches in diameter (Fig. 6). Ordinary bore-rods were employed, a wooden rocking-lever being used to counterbalance

FIG. 6.—BORING HOLES FOR FREEZING-PIPES.

the weight of the rods in the hole. On account of the hardness of the boulders, most of which were whin or dark blue Mountain Limestone, of large size, with ice-worn smooth sides, exceptional difficulty was experienced in boring through this clay, progress was extremely slow, and the holes were constantly liable to deflection from the vertical by reason of the impact of the boring-rods upon the edge of these boulders, which no doubt often moved in their bed of soft clay. It was imperative that the tubes should be vertical, in order to secure an ice-wall of sufficient thickness and of uniform frozen condition. The ver-

tical direction of the holes was tested by suspending a plummet from the surface at a point immediately above the centre of the top of the boring-tube. If during its descent the plummet came in contact with the side of the hole a deviation of the cord was seen at the top of the tube. But in no case was the deviation of any of the tubes found to be more than a few inches.

As soon as a hole had attained the intended depth, the freezing-tubes were inserted. These tubes are 4 inches in outside diameter and 16 feet long, the lowest length having a closed end. The joints consist of a sleeve, 6 inches long,

FIG. 7.—REFRIGERATING-PLANT.

screwed inside to receive the screwed ends of the tubes. As the tubes were being placed in the holes they were tested by hydraulic pressure:—15 atmospheres for the first pipe, 14 atmospheres after a pipe had been added, and so on, reducing the pressure by one atmosphere for every pipe that was added. As soon as the freezing-tubes were inserted, the boring-tubes were removed and used for other holes, so that six sets of boring-tubes were used in putting down 22 holes.

5. *Refrigerating-plant.*—The entire plant (Fig. 7) was provided by Messrs. Gebhardt & Koenig and brought from Germany. The motive power was steam, and was provided by the colliery-owners from two Lancashire boilers working at a pressure of 75

pounds per square inch. The steam-engine, A (Fig. 4, Plate VII.), had an horizontal cylinder, 18 inches in diameter by 20 inches stroke, fitted with ordinary slide and adjustable expansion-valves, and was run at a speed of 90 revolutions per minute. A flywheel, B, 16 feet in diameter, on the crank-shaft was fitted with a belt to drive shafting, C. On this shafting, two pulleys, D and E, were placed, and by means of belts they drove two flywheels, F and G, which gave motion to the cranks of two horizontal compressors, H and I (Fig. 4, Plate VII.). The compressors are double-acting and fitted with conical valves kept in place by springs.

The refrigerating agent, ammonia, is raised by the compressors to a pressure of 150 pounds per square inch. And for this purpose it is absolutely necessary that the gland in which the piston-rod works shall be efficiently packed, or ammonia will escape: the packing consisted of alternate rings of whitemetal, guttapercha and chalked-hemp, with a total length of 15 inches. Provision has also to be made for the continuous injection of oil into the gland, and this was effected by a small pump driven by belting from the main shaft. The oil passes into the cylinder, and, in addition to lubricating, tends to fill up the clearance-space of the cylinders. The ammonia, under pressure, is delivered into a small receiver, where the oil is separated and periodically drained into a lower receiver, whence it is used again. When the oil is mixed with the ammonia under pressure, it loses part of its heat and on being drained into the lower receiver at a pressure of 15 pounds per square inch it has a tendency to freeze, and this is prevented by passing a steam-pipe, ½ inch in diameter, through the oil.

The ammonia leaves the receiver for the condensers, through a pipe, 3 inches in diameter, and thence passes into four tubes, each 1 inch in diameter.

The condensers, J and K (Fig. 4, Plate VII.), are vertical iron cylinders, 10 feet high and 5½ feet in diameter. These condensers contain, in tiers of four rings, 1,600 feet of tubing, 1 inch in diameter, through which the ammonia is circulated. About 4,000 gallons of water per hour circulate through the condensers, and the water is kept in constant motion by means of paddles, *ab* and *cd*, driven by belting from the engine flywheel. This water cools the ammonia, reducing it from a gas to a liquid,

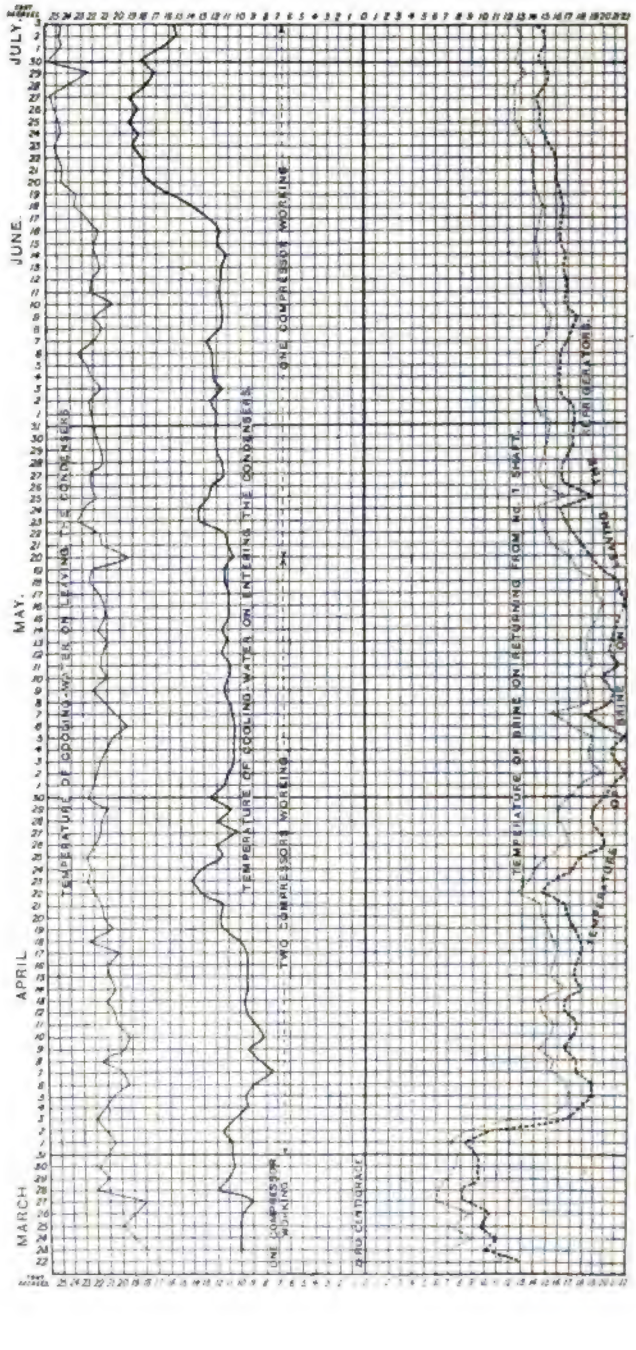


Fig. 8.—Chart of Temperatures of Brine and Cooling-Water.

and the latent heat of liquefaction evolved in the process raises the temperature of this large quantity of water by about 10° Cent. The temperatures of the water on entering and leaving the condensers are recorded in Fig. 8.

When the four pipes emerge from each condenser, they are immediately connected to a pipe, 1 inch in diameter, leading to the refrigerators. The refrigerators, three in number, L, M and N, are vertical iron cylinders 10 feet high and 7 feet in diameter (Fig. 4, Plate VII.). They are jacketed with 3 inches of peat-moss and encased with wooden cleading. They are filled with brine, and contain 2,000 feet of tubing, 1 inch in diameter, through which the ammonia circulates after passing through reducing valves, which has the effect of lowering the pressure from 150 pounds to about 15 pounds per square inch. The ammonia immediately changes its state from a liquid to a gas; and this can only be done by absorption of heat corresponding to the latent heat of vaporization. This heat is taken from the surrounding bath of brine, which is thereby greatly reduced in temperature. Efficient and uniform reduction of the temperature of the brine is obtained by rotating a paddle in each refrigerator, similar to that in the condensers.

The ammonia leaves the refrigerators, passing direct to the suction-side of the compressors, and it keeps constantly passing through the actions already described.

A duplex pump, O, with rams 6 inches in diameter and steam-cylinders 8 inches in diameter by 6 inches stroke, is used to circulate the brine through the tubes in the bore-holes, and back to the refrigerators. This pump makes 60 strokes per minute, and produces a flow of 144 gallons per minute.

On a scaffold, 8 feet above the bottom of the pit, there were placed two rings of pipes (Fig. 9). One ring was connected to the delivery-end of the duplex pump while the return-pipe was connected to the refrigerators. The return-ring also, had separate connections to all the freezing-tubes; and the inlet-ring, conveying the brine, was fitted with tubes, 1 inch in diameter, branching off to every bore-hole. These small tubes entered, through a gland, into the freezing-tubes in the bore-holes, and reached to the bottom. The brine flows down the smaller tube and is discharged through perforations near the bottom of the tube, returning up the outer tube to the return-

ring, and thence to the refrigerators. The connections from the rings to each hole, were fitted with cocks so that the supply and return side could be closed at will. The pipes, after the freezing commenced, were soon coated with ice; and, to ascertain that each pipe was receiving its proper supply of brine, a few square inches of ice was cleared every morning, and the rapid formation of ice on the exposed part was proof of satisfactory working. Fig. 8 records, for each day, the average temperatures of the brine as it left the refrigerators and as it returned from the shaft. As a rule, the temperature was increased about 2° Cent.

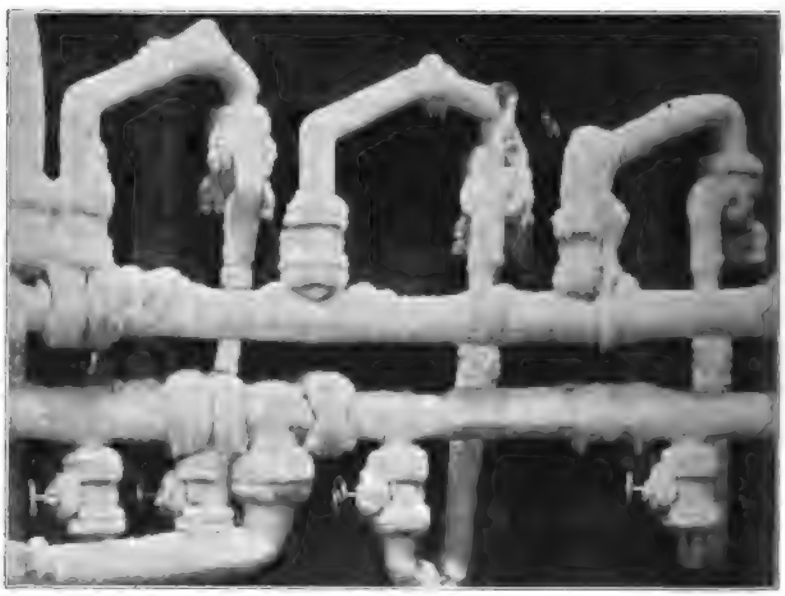


FIG. 9.—RINGS AND CONNEXIONS TO FREEZING-PIPES.

The brine, which is used to freeze the quicksand, circulates in tubes sunk at intervals in the sand, and has its temperature lowered below that of the freezing-point of water, being robbed of its heat in the refrigerators, previous to circulation by the pump, owing to the vaporization of the ammonia on its way to the suction-side of the compressors.

6. *Agents.*—The refrigerating agent used was anhydrous ammonia (NH_3) and while other agents (carbonic acid, sul-

phurous acid, etc.), can be used, ammonia is considered to be the most efficient, and certainly the most harmless in case of accidental escape. This substance has a molecular weight of 17, and as a gas had a density in relation to hydrogen of 8·5 and in relation to air of 0·59, and boils at −40° Cent. at atmospheric pressure. It has a latent heat of vaporization of 287 calories, and a vapour-tension of 108 pounds per square inch at a temperature of 16° Cent. Gaseous ammonia can be liquefied at a pressure of 128 pounds per square inch at a temperature of 21° Cent.; and at a pressure of 150 pounds at a temperature of 25° Cent., the pressure required to produce liquefaction rising very rapidly with the temperature. The latent heat of ammonia is very great, consequently its value as a refrigerating agent is proportionately large. It possesses greater heat-absorbing properties than other agents, and it liquefies at a comparatively low pressure. It acts injuriously on copper and brass. It is combustible, and when mixed with twice its volume of air is capable of exploding with great violence. The ammonia was brought from Germany in steel cylinders, 4 feet long by 8 inches in diameter, at a pressure of 300 pounds per square inch.

The brine used consisted of a solution of chloride of magnesium. The salt was dissolved in hot water, the resultant brine consisting at first of 21 per cent. and being gradually raised to 26 per cent. of the salt. The latter solution freezes at a temperature of −34° Cent. It will therefore be seen that it is capable of circulating in tubes at a temperature that would solidify any water in contact with the tubes. A float was used to indicate the height of the brine in the refrigerators, so that any abnormal leakage would be detected. The quantity of brine was kept constant.

Before commencing the freezing process, the top of the shaft was enclosed, and the exposed pipes were covered with straw-ropes. A hole was bored, and a pipe 18 feet long inserted, in the middle of the shaft, and the height and temperature of the water in the hole was noted as the gradual increase of ice-wall slowly caused the water to rise.

7. *Difficulties.*—No special difficulties or accidents were experienced. There were a few cases of the packing being blown out of the compressor-glands. A slight shrinkage, owing to the

temporary character of the foundations, caused the crank-shaft to heat on several occasions. One of the freezing-tubes split, probably owing to the effect of a shot, the leakage of the brine was seen in the side of the shaft, and the connections to the supply and discharge-rings were immediately closed. The brine was withdrawn, and the pipe thrown out of use.

Owing to a missed-shot, one of the sinkers working in the shaft-bottom struck a gelignite-cartridge with his pick, causing it to explode, and he received injuries that resulted in his death, 4 days later. Eight other workmen were in the shaft-bottom at the time, and all received slight injuries. Two similar accidents, happily, without fatal results, occurred while using the same explosive, at a sinking in Northumberland, three and four days later respectively, so that the accident could not be alleged to be due to special circumstances connected with the freezing system. Probably, the quality or condition of the explosive may have been such that missed-shots were likely to occur.

The large quantity of water used for cooling the ammonia, in the absence of a reservoir, rendered cooling arrangements necessary, and this was accomplished by allowing the water to trickle through perforated boxes.

8. *Excavation.*—On May 5th, 1902, forty-three days after freezing commenced, the excavation of the frozen ground was commenced. The shaft was sunk 17 feet 10 inches in diameter, and the freezing-tubes extended 16 inches beyond the sides. The comparatively dry sand was found in a hard state near the sides of the shaft, but it readily yielded to the pick. The 6 feet core in the centre of the shaft was always soft, and in the quicksand the latter was in its natural wet condition. Ordinary cribs and backing-deals were used to secure the sides of the shaft to a depth of 18 feet. In passing through the quicksand, pointed chisels struck by hammers were a valuable aid to the pick, and the working-time occupied in sinking the length of 55 feet through the sand was only 11 days. The wet sand contained 19·6 per cent. of water by weight or 37 per cent. by volume.

On entering the clay, the aspect of affairs altered. Probably owing to the higher conductivity of the clay, the ice-wall was much thicker, and the soft central core was partly

frozen, and never more than 2 feet in diameter. The clay was full of stones or boulders, varying in size from a pea to 3 feet in diameter: coal in small pieces, shale, sandstone, Mountain Limestone, red and grey granite, and whin all being represented. Some of the larger limestone-boulders were striated, showing the effect of glacial action. In the clay, recourse was had to blasting, but on account of the brittle condition of the tubes carrying the cold brine, the depth of the shot-holes was restricted to 42 inches in the sump and 30 inches in the canch. A shot was not allowed to be placed within 15 inches of the side of the shaft, and it was sloped at an angle of not less than 20 degrees to the centre of the shaft. The quantity of gelignite was restricted to ½ pound in each hole. Under these conditions, the comparative inefficiency of the pick, on account of the clay being of a tough leathery nature, and the boulders large and numerous, caused progress to be extremely slow, and the freestone was not reached until June 10th, 1902. In drilling the holes in the clay, brine was used, as water quickly froze and held the drills in the holes. Ordinary wooden cribs, 6 inches square, with backing-deals, were used in securing the dry sand, and for a length of 6 feet in the wet sand iron rings were used to keep the backing-deals in position; but, in neither case, was it necessary to secure the sides, and the remainder of the sinking was finished without supports.

9. *Permanent Lining.*—As soon as the freestone was reached, water was seen in the bottom of the shaft, and a bed was prepared for a cast-iron ring made in eight segments, 20 inches on the bed, and 2 inches thick. The edge was turned up at the front so as to form a water-ring. Oaken sheathing, 1 inch thick, was placed between the segments, and bolts were passed through the flanges and sheathings.

A solid wall of bricks and cement-mortar was built on the cast-iron crib: the bricks being shaped at the ends so that, although set back 4 inches from the front at the first course, they came gradually into the required size of the pit at a height of 5 feet above the crib. At 18 feet above the crib, the walling was altered to two concentric rings of brickwork, each 9 inches thick, and the intervening cavity, 2 inches wide, was filled with cement. Three stretcher-courses alternated with one header-

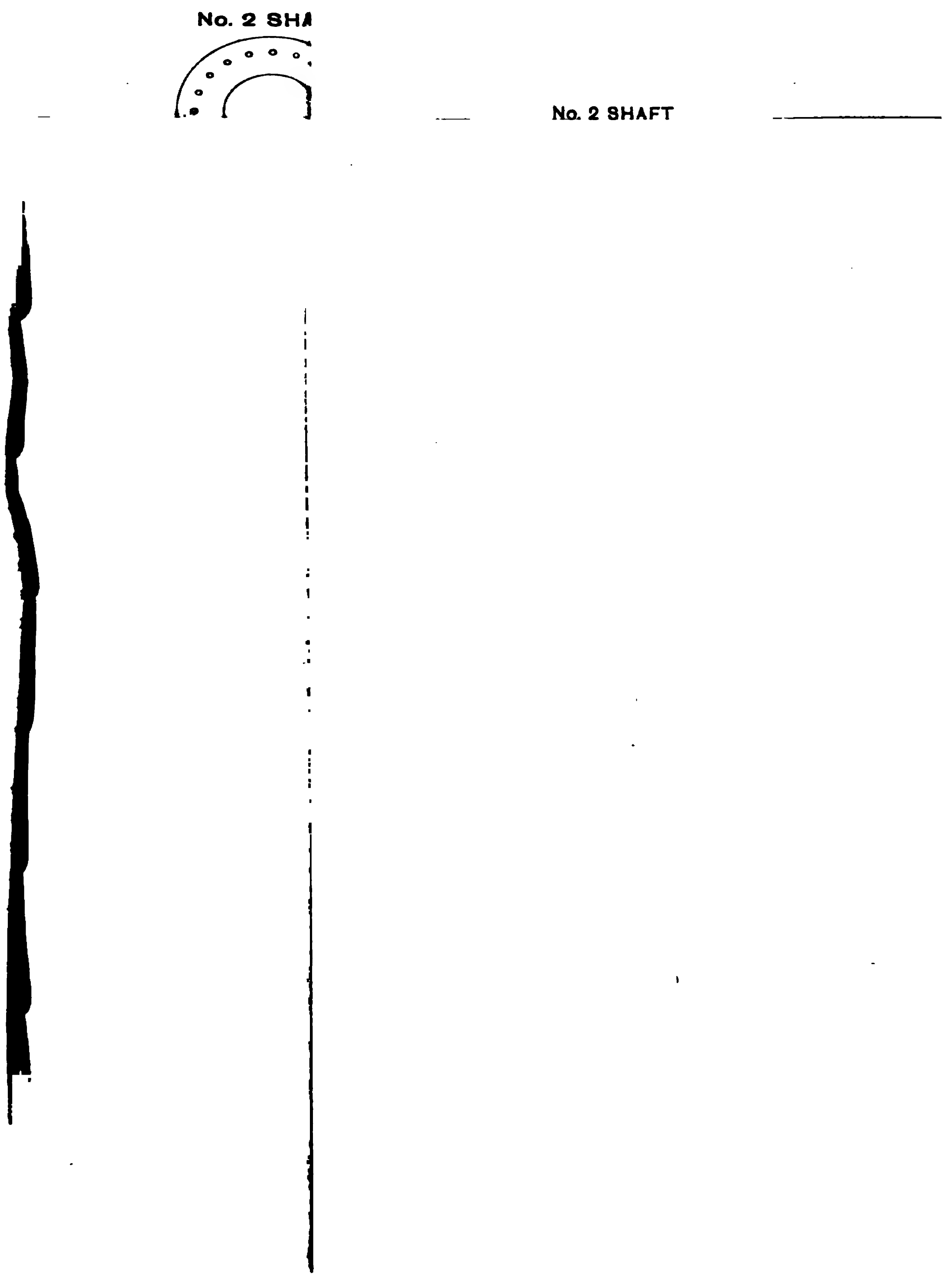
course. To prevent the cement-mortar from freezing, the mixing water contained 7 per cent. of caustic soda. The soda was dissolved in hot water. The cement-mortar consisted of 1 part of cement to 2½ parts of dry yellow sand taken out of the pit. The sand was not very sharp. The bricks (9 inches by 4½ inches by 3 inches) were obtained from a colliery in the vicinity, made from a seggar or coarse fire-clay, and locally termed "plate-bricks." One side of the brick was curved to suit the circle of the shaft.

10. *Extraction of the Tubes.*—The removal of the freezing-tubes was commenced, as soon as the walling was completed, above the water-bearing strata. By means of the inner tube, steam was used to thaw the surrounding strata. A pair of hydraulic jacks were used to move the tubes, and they were then drawn out by the sinking-engine. The outside socket-joints increased the labour of removing the tubes, and two weeks expired before the work was finished; and in two cases the bottom length of the tubes was left in the holes, as the screw-thread at the joint had stripped by the force applied. As the tubes were withdrawn, the holes were filled with cement-mortar consisting of 1 part of cement to 3 parts of sand, so as to prevent the sand-feeder from passing through the clay into the freestone.

11. *Conclusion.*—There can be no doubt as to the reliability and efficiency of sinking by the freezing system through water-bearing strata; and with ordinary care, the possibility of a mishap is very remote. In the present case, the slow progress of the sinking was due to the boulder-clay, and a large amount of time was spent in boring and sinking through it. Opinion varied as to the desirability of freezing the boulder-clay, in the circumstances of the case under discussion; but the contracting firm held that it was absolutely necessary that the boulder-clay should be frozen.

Mr. T. E. Forster (Newcastle-upon-Tyne) asked whether any difficulty had been experienced with the walling, since the ground had been thawed; and whether there had been any difficulty in the setting of the cement, while the ground was frozen.

"To i ethod at Washington, County Durham."



Prof. H. Louis (Durham College of Science) asked whether the contractors had changed their opinion with reference to boring the holes through the boulder-clay and into the solid freestone. Many engineers who saw the process at Washington, could not imagine any valid reason for freezing this clay; but the contractors stated they had experienced considerable trouble in freezing strata containing boulder-clay in Germany. He (Prof. Louis) imagined that these were only lenticles of clay lying in the quicksands, and did not compare with the immense beds of boulder-clay found in this country.

Mr. J. K. Guthrie (Preston) said that he had sunk a shaft (14 feet in diameter) through boulder-clay in the ordinary way, putting in cribs, etc., and no trouble whatever had been experienced.

Mr. A. Gobert (Brussels) wrote that he noted with pleasure that the Centigrade thermomenter had been adopted for observations of the temperature of the brine and cooling-water, and he would suggest that British mining engineers should also adopt the Continental calorie as the unit of heat, as by so doing it would be much easier to compare results obtained on both sides of the Channel. The description of the permanent lining used at Washington was interesting, but he would like to have some indication as regards prices. The question of cost might also be usefully discussed for all parts of the process of walling. He might point out that very important sinkings by the freezing process were contemplated in Belgium, and it was expected that the soil of Brussels would be frozen for the line of railway to be made between the Nord and Midi railway-stations. The government had consulted the writer, and he had given them a complete report upon the subject.

Mr. F. R. Simpson (Ryton) said that he had read Mr. Ford's paper with interest, not only because he had seen the process in operation at Washington, but he had recently made himself acquainted with what was being done by this method on the Continent. There, it was recognized as one of the regular methods of sinking through sands, either at the surface or at great depths. At one colliery, a shaft had been sunk by this method to a depth of nearly 800 feet. Difficulties had been ex-

perienced in boring vertical holes, and from the breaking of the pipes, but in every case these difficulties had been overcome, and he had not heard of any case in which there had been failure to complete the shaft in the contracted time. The members were indebted to the Washington Coal Company, Limited, for showing what could be accomplished by this method of sinking, and there could be no doubt that the sands met with in the east of Durham, could be successfully sunk through with the assistance of the freezing method. He moved that a vote of thanks be accorded to Mr. Ford for his valuable paper.

Mr. J. G. WEEKS (Bedlington), in seconding the vote of thanks, said that the recent excursion of the members to Washington colliery had been most successful.

The vote of thanks was cordially approved.

Mr. MARK FORD, in acknowledging the vote of thanks, said that a slight feeder of water was coming through the walling. The addition of caustic soda to the mixing water prevented the cement from freezing, and allowed time for its setting. Before sinking the second pit, he wrote to the contractors as to whether they still considered it necessary to freeze the boulder-clay; they maintained their previous opinion, and stated that they absolutely refused to take any responsibility as to the sinking of the shaft unless the boulder-clay was frozen.

Mr. JAMES STEWART's paper on "The Valuation of Gas-coals" was read as follows:—

THE VALUATION OF GAS-COALS.

By JAMES STEWART, Editor of the *Gas World*.

The valuation of coal for gas-making purposes is peculiar in that no ordinary laboratory-method of analysis, such as serves to value most technical materials, will suffice. It is not like lime, for instance, the value of which, either for gas-purification or as a cement, can be inferred from its chemical analysis; nor like a lubricant, the utility of which can be estimated from its behaviour when exposed to certain physical and chemical tests. An ultimate analysis, revealing the elementary constituents of the coal, may perhaps show its fitness or otherwise for gas-making, but it is no trustworthy guide as to its value for that purpose. And a proximate analysis, showing the respective amounts of volatile and fixed products when the coal is subjected to destructive distillation, is of little, if any, greater utility. The actual value of a gas-coal can only be ascertained by imitating the treatment which the coal will receive in the gas-works, and thus producing from it the gas and bye-products for which it is valued.

The scale on which the process is carried out may vary considerably, according to the resources at command and the preferences of the operator. The minimum, however, is fixed, in that at least sufficient gas must be produced to enable its illuminating power to be determined by the Bunsen photometer; which means that not less than 1 pound of coal, yielding, say, 5 cubic feet of gas, must be carbonized. Ordinarily the laboratory apparatus is of little more than twice this minimum, and carbonizes at one operation 2¼ pounds of coal, which is practically 0·001 ton. The experimental plant of a modern gas-works is generally on a much larger scale, being arranged to carbonize 1, 2, 3 or 4 cwts. of coal at once; and in a few cases it is on a scale of still greater magnitude, constituting, in fact, a small gas-works in itself.

In skilled hands, the small laboratory-apparatus abovementioned is able to furnish very trustworthy results; but it has the drawback of almost invariably attributing to the coal a higher value than is borne out on the working scale. And, paradoxical as it may seem, this failing is likely to be the more accentuated in the hands of the less experienced operator. The reason for this will be seen on a brief review of some of the particulars wherein the laboratory-apparatus necessarily differs from the actual plant employed in the gas-works:—

(1) The retort is of iron, which is a better conductor of heat than clay, and can always be ascertained to be perfectly sound before making a test; whereas the clay-retort in the gas-works is of a porous nature, and has to be made tight by rendering with cement or by filling up its pores with deposited carbon, and is therefore more liable to spring accidental leaks. Then, (2) the temperature is under complete control and, if not high enough, a test can be delayed until the proper heat is attained; or experiments may be made to find the most suitable temperature for obtaining the best results from the coal. Again, the coal will usually be perfectly dry before it is introduced into the retort, and that introduction will be effected with such celerity that no gas is lost in the operation; whereas, in practical working, there is necessarily a considerable loss of gas ere the lid of the retort can be closed and sealed. And there is some slight further advantage in the fact that the gas is measured at a pressure little if at all above the pressure of the atmosphere; whereas, in the gas-works, there is an additional pressure, generally of 6 or 7 inches of water, due to the weight of the gasholder.

But there is another particular in which the laboratory-method differs from the working-scale operation that, perhaps more than all those above enumerated, allows of unduly favourable results being obtained; and that is the different treatment in the matter of condensing, washing and scrubbing, which the gas receives. With the very best intention to obtain trustworthy results, it is impossible to subject the gas to the same rigorous treatment in the laboratory as it receives in the gas-works. Owing to the smallness of the scale on which the operation is conducted, the gas cannot be washed and scrubbed with ammoniacal liquor and clean water, as is done in the gas-works, without using a proportionately much greater quantity of the

liquids, and so overdoing the cleansing—to the great detriment of the gas. Therefore it is usual to dispense with the washing process, and the experimenter is content with cooling the gas to a sufficient degree, before purifying. Unfortunately mere cooling, except when carried to an extreme, does not suffice to rid the gas of the minute vesicles of tarry hydrocarbons (which are carried along with the stream in an exceedingly minute state of division, and require prolonged contact with wetted surfaces, combined with some stagnation of flow, to enable them to coalesce into drops of liquid, and so allow of their removal from the gas). If every trace of these condensable hydrocarbons be not removed before the gas is tested for its illuminating power, its quality will appear unduly exalted. For the illuminating power of coal-gas is due to its containing from 4 to 6 or 7 per cent. of heavy hydrocarbons, which, in their composition and nature, greatly resemble much of the liquid constituents of the tar; but differ from the latter in the important property of being, under ordinary conditions, uncondensable from the gas. A very slight increase in the percentage of hydrocarbons, which may be caused by inefficient condensation, is therefore calculated to make a considerable difference in the result on the photometer. And if such a result may obtain with every desire to be fair, what may not be done when the gas is purposely coddled with a view to high results?

Sufficient has been said to show how a much higher value can be attributed to the coal than it may really have for the practical gas-maker. By how much the estimate should exceed the reality has never been determined, though many opinions have been hazarded. It is, in fact, incapable of solution. However carefully and conscientiously the test may have been carried out, it is hopeless to attempt to predicate from the result the corresponding result that will be obtained in the gas-works. It must obviously depend upon the skill and intelligence brought to bear upon the working, as well as on the degree of perfection of the plant employed. While, therefore, it will be the aim of the analyst to arrive at the ultimate value of the coal, he must ever keep in view the actual conditions of gas-making, and not take advantage of his favouring circumstances to obtain results which cannot, even with the exercise of great care and skill, be realized in practice.

There is one other matter that requires to be taken into

consideration in interpreting the results of a coal-test; and that is the question of the burner with which the illuminating power of the gas is determined, including the manner in which it is used. Obviously the burner used should be the standard one for the particular quality of gas, that is to say, the London argand for qualities up to 18 candlepower, and the batswing for qualities of 19 candlepower and upwards. But it is neither necessary nor desirable that it should always be used under standard conditions. Under the absurd regulations which, everywhere but in London, govern the testing of coal-gas, the illuminating power has to be determined with a fixed consumption of exactly 5 cubic feet per hour. When burning different qualities of gas in the argand burner, a uniform consumption must be prejudicial to the lower qualities; because more air is drawn upon the flame than is required, thus cooling and over-oxidizing it, with the result of depreciating the illuminating power. The analyst should therefore vary the consumption to suit the quality of the gas, and calculate the result to the 5 cubic-feet rate. But, if this be done, it is very important that the fact should be stated in the report, so that the gas-manager may know that he has to expect a less satisfactory result when the gas is consumed at the standard rate.

Mr. W. Doig Gibb (Newcastle-upon-Tyne) wrote that the teaching of Mr. James Stewart's paper on "The Valuation of Gas-coals" was that what was known as a "laboratory test" would not give results comparable to those which could be obtained in actual working. This had been known for a long time. The paper was, however, of value in that it marshals the arguments for and against the "laboratory test" in a terse and lucid manner. In larger gas-works, where the capital expenditure required could be afforded, there was no doubt that an experimental plant on a working scale was of much greater advantage to gas engineers generally than a laboratory plant could be, but even then it was still a benefit to have a laboratory-plant in addition, since, with the latter, tests could be taken quickly and without great cost, and though the results might not be comparable to the actual working-results they were trustworthy (if proper care were taken in testing) in comparing the different results got from the various coals tested. Mr. Stewart did not seem to believe in the future

possibility of the tests on a laboratory-plant being made in such a manner as would approximate the results got on a working scale. It might not be possible, but at all events it would be a step in the right direction if standard laboratory apparatus and standard methods of using the same were adopted. This would at all events result in the different published analyses of coal being comparable with each other. At present, owing to the different methods employed in sampling and testing, and also owing to the absence of any information on the printed analyses sheets as to the methods, etc., employed, an interested reader had great difficulty in comparing, in any accurate way, the value of one with another.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Stewart for his interesting paper.

Mr. G. MAY seconded the vote of thanks, which was cordially approved.

DISCUSSION OF MR. G. P. LISHMAN'S PAPER ON "THE ANALYTICAL VALUATION OF GAS-COALS."*

Mr. G. P. LISHMAN wrote that the main intention of his paper had been to emphasize the advantage derived from the regular introduction of a coal of known value into the testing of an unknown coal. This certainly introduced other difficulties, as Dr. Pattinson had pointed out, but in his (Mr. Lishman's) opinion they were considerably less than those which were overcome. A colliery-manager knew fairly well that certain of his seams varied in quality, and that others were very constant; and this, combined with his (Mr. Lishman's) own knowledge, derived from testing, led him to adopt the coal of the Maudlin seam at one of the Lambton collieries as his standard, whereby others were checked. The method had been in use, with great advantage, at the Lambton collieries for over two years; still it was not claimed that perfection had been reached, as the introduction of further refinements was desirable and might reasonably be hoped for. He (Mr. Lishman) did not entirely understand Mr. W. D. Gibb's alternative suggestion from the outline given, but possibly there might be some manner of cômbining it with the standard-coal method.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 567; and vol. xxiv. page 166.

The difficulty was that in winter the iron of the purifiers and pipes (apart from the condensers, which might if necessary be kept warm) was very cold, and owing to this the illuminating power of the gas made in winter-tests was usually of 14 to 16 candlepower as against 16 to 18 candlepower obtained in summer. The purifiers and all the other pipes, except the condensers, were not water-jacketted—it would hardly be practicable to have them so—this perhaps best supplied the answer to Dr. Pattinson's query on the subject. No doubt, the effect of condensation was increased by the slower passage of the gas; and, if, as mentioned by Mr. Gibb, the entire room in which the gas was treated were kept at a constant temperature in summer and winter, there would be no necessity either for water-jacketted condensers or even a standard coal. Probably, a room could be arranged so that this might be effected, but in his (Mr. Lishman's) particular case the controlling of the room-temperature was found to be so troublesome that the idea was given up.

The time required for distillation was a question of retort-temperature, and when he (Mr. Lishman) stated 60 to 90 minutes, the latter was an outside limit seldom reached: one hour was regarded as the regular time for a test, but if any further gas was coming away at the end of that time the distillation was allowed to proceed until it ceased, or nearly so. The usual time actually taken varied from 60 to 70 minutes. It was frequently stated that the results from a laboratory coal-testing plant were higher than those likely to be obtained in a gas-works, but this by no means followed, and it depended entirely on the amount of condensation or scrubbing applied. The effect of the lower retort-temperature was to increase the illuminating-power, the yield being reduced.

Mr. Stewart took the writer to task on the two statements that "there is an almost total absence in scientific journals of papers on the testing of gas-coal" and that "although coal-testing plants are attached to most gas-works now, they are usually of but limited use to the engineer, who still has to rely mainly on his working-scale results." He (Mr. Lishman) did not wish to appear contentious on minor points such as these, more especially as Mr. Stewart agreed with him on the main issues of the paper, but considering the enormous number of papers published on all gas-matters in these days, the three or

four papers on laboratory-testing of gas-coal which had been published in the last ten years could hardly be regarded as numerous. Perhaps the best of them was that of Mr. Thomas Glover, read before the Midland Association of Gas Managers in 1896, but the scale was much larger than that referred to in the present paper. If there was any German or other literature of which he (Mr. Lishman) was ignorant, he would be very glad if Mr. Stewart would point it out.

Regarding the second statement, he (Mr. Lishman) had evidently credited more gas-works with coal-testing plants than actually possessed them, but this was not Mr. Stewart's point. The idea that coal-testing plants were of limited use to gas-engineers was a general impression from his (Mr. Lishman's) knowledge of the industry. Since Mr. W. Doig Gibb was evidently in agreement with him on this point, he saw no immediate reason to alter his opinion on the subject. The underlying assumption in the early part of Mr. Stewart's remarks (scarcely carried through to the end) that gas-coal testing was, and had been, for many years, a sufficiently simple matter to those concerned, would hardly meet with wide recognition.

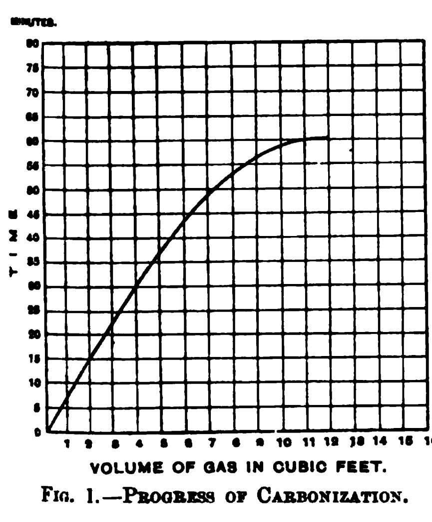


FIG. 1.—PROGRESS OF CARBONIZATION.

With reference to the use of a standard coal, Mr. Stewart said that "the idea is not, of course, entirely original," but as it was stated in his paper that "at any rate the idea is by no means novel" Mr. Stewart's remark was apparently unnecessary.

An interesting point had been raised, that the sperm-value of a coal was not always the measure of its value to the gasmaker; for with two coals of equal sperm-value one might take longer to carbonize than the other and therefore be more costly. This was so, and the difference between two such coals would not be indicated by any figure in the analysis. Eight or nine years

ago, the writer made observations of the volume of gas given off every five minutes during a test, and diagrams (similar to Fig. 1) were prepared, which indicated the progress of the carbonization. As the diagrams obtained from the coals then tested, were mostly very similar, the practice was discontinued. Coals from different parts of the country, however, were known to vary greatly in this respect, and he (Mr. Lishman) thought that such a diagram might with advantage be appended to the analysis of a gas-coal. In comparing diagrams made at different times, it should be borne in mind that differences of retort-temperature might have somewhat altered the general direction of the line, but this need not confuse the experienced diagram-reader.

It would be an advantage to many chemists, besides those actually engaged in making tests on gas-coals, if Dr. Anderson's suggestion, as to the adoption of a single standard gas-coal for the whole country, could be carried out. Perhaps this was too much to hope for at present, but the interests involved were considerable, and many might be found to support such a scheme.

Dr. Edward Dyer Peters' paper on the "Treatment of Low-grade Copper-ores" was read as follows:—

TREATMENT OF LOW-GRADE COPPER-ORES.

BY DR. EDWARD DYER PETERS.

Introduction.—In the introduction to Mr. Muir's paper* reference was made to the fact that extremely low-grade ores are treated in the Lake Superior district of the United States of America, one of the mines actually finding it profitable to work an ore that contains only 0·65 per cent. of copper, or 13 pounds of the metal to a ton (2,000 pounds) of the ore.

It seemed to the writer that when making use of Lake Superior results, as a standard of comparison, in a paper on the treatment of sulphide-ores of copper, reference should be made to the fact that the conditions at Lake Superior are extraordinary, and unparalleled anywhere else in the world. It is, of course, wellknown to all who are interested in copper that this metal, in the Lake Superior veins, occurs in minute (and sometimes large) particles of pure metal, that only require a cheap washing process to be recovered in a nearly pure state; and that a single refining operation yields ingot-copper of the very highest grade and value. To the public at large, therefore, should be afforded the opportunity of realizing that the metallurgical operations at Lake Superior do not furnish a standard that can properly be compared with any other mining district in the world.

Mr. Muir is grappling in Australia with almost exactly the same problem as that which confronts many of us in the United States. For, although we have the unusually rich and extensive copper-areas of Montana, Arizona and Utah, we have also far greater areas of low-grade, disseminated and highly siliceous sulphide ores, situated far from a market and from fuel, and too often scantily supplied with water. Mr. Muir, in his paper, and Mr. Eissler, in his discussion of the same, had so covered the ground that there did not seem to be much new to say on the subject. Still, the writer would venture to offer a few suggestions based upon his own experience, as well as upon information

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 517.

derived from engineers who have devoted much time to this class of ores.

In order to narrow the field of enquiry, it may be well to enumerate all the methods that seem to have any claims at all to consideration, in connection with the treatment of the ores in question. We may then eliminate all those processes that, on examination, appear economically inapplicable, and consider the few that then remain. (1) Direct smelting; (2) mechanical concentration, followed by the smelting of the concentrates and the lixiviation of the tailings; (3) lixiviation of the ore direct, with a solution of ferrous chloride and salt; (4) lixiviation of the ore direct, with hydrochloric and sulphuric acids, which are regenerated in the solution by the precipitation of the copper from a chloride solution by means of sulphurous acid; (5) lixiviation of the ore direct, with sulphuric acid; and (6) the Rio Tinto method of gradual lixiviation in heaps.

1. *Direct Smelting.*—Wherever it is in any way practicable, the American metallurgist prefers smelting to any form of wet process. The perfect continuity of the operation, the ease and simplicity with which the unpulverized ore pursues its steady course from the mine to the blast-furnace, from the blast-furnace to the converter, and from the converter to the refinery, lend themselves to operations on a very large scale, and permit the substitution of mechanical appliances for hand-labour to an extent unapproachable in any other method. Another great advantage of smelting (absent in the present case) is the almost complete recovery of the precious metals present, with but little extra cost.

Nor need we be deterred from the employment of direct smelting, by even a very considerable excess of silica, and a corresponding deficiency of iron in the ore. Perhaps this was most clearly pointed out by Mr. F. R. Carpenter in the Deadwood and Delaware smelter, South Dakota, U.S.A. He demonstrated conclusively that highly siliceous ores, containing a little pyrites, and with extremely expensive coke, could be smelted direct in the blast-furnace, with the production of slags containing 50 per cent. of silica, 30 per cent. of lime and magnesia, and only 16 per cent. of ferrous oxide. The lime and magnesia were added to the ore in the form of barren dolomite; 20 to 30 tons of ore

produced 1 ton of matte; the slags were exceedingly clean; and the precious metals and copper (very little) that were contained in the ore, were almost entirely recovered in the matte.

The most interesting features of this unusual type of smelting are the fusibility of the very acid silicate of lime and magnesia with but little iron, and the high rate of matte-concentration. The latter result is due to the very acid slag which decomposes the pyrites present, carrying their iron-contents into the slag as ferrous oxide. It is not always understood by blast-furnace smelters that, other things being equal, an acid slag means a high-grade matte, while a basic slag is accompanied with a low-grade matte.

The writer has only gone into this detail in regard to the direct smelting of very siliceous ores in the blast-furnace in a raw state, in order to call the attention of metallurgists to possibilities that may solve certain difficult metallurgical problems.

In the case cited by Mr. Muir, however, it may be feared that the absence of silver or gold in the ores, and the non-existence of limestone-ores for fluxing purposes, with the high cost of fuel, would compel us, most reluctantly, to give up the idea of direct smelting.

2. *Mechanical Concentration, followed by the Smelting of the Concentrates and the Lixiviation of the Tailings.*—The writer has met with, or been cognizant of, so many difficulties and failures in attempting to concentrate low-grade, disseminated sulphide ores of copper, that he has always advised exhaustive mill-tests on a large scale before venturing to employ this method. It is only suitable for very exceptional ores and conditions.

Mr. Muir's results seem to be stronger arguments against the employment of this process than any that the writer could adduce.* Without attempting to analyse his experiments in detail, the writer would simply point out that the results of Mr. Muir's concentrating tests show a saving in the concentrates amounting to about 20 per cent. of the original copper contained in the ore, and a loss of nearly 80 per cent. in the tailings. This, of course, means no concentration whatever, and there must be some reason, not apparent to the writer, why Mr. Muir attempted to concentrate at all.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., pages 520 and 521.

If a portion of the copper in the ore were present in the shape of some mineral that would exercise an injurious effect upon the subsequent lixiviation, and if this mineral had a higher specific gravity than the remainder of the sulphides present, there might be some question of attempting to remove it by concentration. But, as the 20 per cent. of the copper that was removed by concentration had, as the writer understands, exactly the same chemical composition as the 80 per cent. left in the tailings, he fails to see the use of employing concentration; nor does he believe that these ores should be subjected to concentration. (It will be understood that the writer is referring solely to the ordinary methods of wet-concentration in making this statement, and that he is not expressing any opinion as to the results that might be obtained by one or two novel patented methods of which he has no personal experience.)

It seems to the writer most advantageous, therefore, to subject the entire mass of ore to lixiviation, rather than to complicate matters and increase expenditure by any preliminary concentration.

3. *Lixiviation of the Ore direct, with a Solution of Ferrous Chloride and Salt (old Hunt-and-Douglas Method).*—Considerable quantities of ore have been successfully worked by this process in the United States. The method depends upon the fact that oxide of copper is decomposed by ferrous-chloride solutions, forming insoluble ferric oxide, while the copper goes into solution as cuprous and cupric chlorides. It is precipitated in a very pure metallic form by iron, the ferrous-chloride solution being thus also regenerated, and requiring only the addition of a little salt to fit it for further use. The consumption of metallic iron in this method is very small, as much of the copper is in solution as cuprous chloride.

As the copper must be in an oxidized form, in order to go into solution quickly and thoroughly, the ore will require a preliminary roasting of sufficient thoroughness to convert most of the copper present into oxide or sulphate. This means that the ore must be crushed dry, though not to nearly so fine a state as would be required for its concentration. Therefore, instead of wet crushing followed by concentration, the writer would suggest dry crushing followed by roasting.

It is impossible to make a comparison of the costs of these two different plans of operation without being accurately acquainted with the physical and chemical character of the ore under consideration. By the use of modern high-speed rolls of great diameter and weight, and of the automatic reverberatory roasting-furnaces so generally in use in the United States of America and elsewhere, the cost of dry-crushing and roasting should not exceed the cost of wet-crushing and concentration, while the condition of the pulp for lixiviation is incomparably better when produced by the former treatment. Apart from the advantage gained by the coarser condition of the pulp, and the much lesser proportion of very fine powder, the ore undergoes a physical change in roasting, which makes it much like sand and gravel, and enables the solutions to permeate it with a completeness and rapidity that are quite surprising. The advantages thus gained will only be fully appreciated by those members who have had experience in leaching the same ore both before and after roasting. They are so great that, in several instances in this country, tailings are roasted previous to lixiviation, solely for the purpose of improving their physical condition, and of increasing the thoroughness and rapidity of the latter operation.

The writer desires to emphasize this dry crushing and roasting as being, in his opinion, the most important step towards a successful leaching of these ores by the methods that he has called Nos. 3, 4 and 5.

4. *Lixiviation of the Ore direct, with Hydrochloric and Sulphuric Acids, which are regenerated in the Solution by the Precipitation of the Copper from a Chloride Solution by means of Sulphurous Acid (new Hunt-and-Douglas Method).*—By this method, the copper is precipitated from its chloride solution, by means of sulphurous-acid gas, which throws down the copper as a very heavy white cuprous chloride, that settles almost instantaneously. Sulphuric and hydrochloric acids are generated in the solution, which only requires the addition of salt to make it ready for further use.

One great advantage of this method is the rapid dissolving of the oxidized copper present by the strongly acid solution, which even attacks sulphides with considerable energy. Any lead and silver present remain undissolved. The ores require to be

roasted, as in the previous process. A supply of pyrites is essential to the economical working of this method, and, of course, it is very advantageous if these pyritic ores contain some metal of value.

5. *Lixiviation of the Ore direct, with Sulphuric Acid.*—Mr. Muir has already considered this method in his paper, though he confined it to the treatment of the tailings after concentration.

The writer can only add that, if lixiviation is at all suited to the fine tailings and slimes from the concentration-process, it is still more feasible, and much more economical, when employed upon the coarsely-crushed and roasted ore; and, that instead of taking 11 weeks for the extraction of the copper, it is probable that, with roasted ore, an equally perfect extraction would be accomplished within 2 or 3 days.

6. *The Rio Tinto Method of Gradual Lixiviation in Heaps.*—The writer agrees with Mr. Eissler in having a strong leaning towards this process of slow, but inexpensive, lixiviation, in cases where the climate is suitable, and where the chemical and physical condition of the ore favours the gradual and persistent formation of sulphates. From the description of the ore given by Mr. Muir, the writer fears that, in the present instance, the percentage of sulphides might not be large enough to maintain the energetic and persistent chemical action necessary for the gradual decomposition of the chalcopyrite, and the formation of soluble salts of copper.

There is another very serious objection to the Rio Tinto method that does not always weigh sufficiently with the metallurgist, who confines his attention too closely to the perfection of his technical results, namely:—The time and money required to demonstrate on a large and safe scale that any given ore will eventually yield up its copper to this slow and tedious process. There is also great difficulty in finding reliable deposits of sufficient size to yield the enormous quantities of ore of a nearly identical composition that are required for the profitable instalment of this method, as well as in raising capital willing to wait so long for returns.

[illegible]letes the list of methods that seem to the writer [illegible]leration in connection with Mr. Muir's Australian [illegible] one or two recent British patented methods that

bear on this same subject. No doubt they have been investigated by British engineers who are interested in the mechanical concentration of difficult copper-ores, and the writer does not feel at liberty to discuss them in this place.

Recapitulation.—After enumerating the six methods of treatment that seem to the writer to be best suited to these Australian ores, he has eliminated the first two, namely:—(1) Direct smelting, and (2) mechanical concentration and lixiviation of the tailings. The slow Rio Tinto method of leaching, which he has called No. 6, demands most careful consideration in the few cases where the magnitude of the ore-bodies and of the financial resources will permit of its application.

This leaves only the three methods of direct and rapid lixiviation of the ore without any previous mechanical concentration. An intimate knowledge of local conditions and costs, wide technical experience with modern lixiviation-methods, and long and careful experiments on an extensive scale, on the ore to be treated, can alone decide the method to be chosen.

The writer is pretty well convinced, however, that if the choice should fall upon any one of these three methods, it will be found advantageous to crush the ore dry and roast it, before lixiviation.

Mr. JAMES DOUGLAS (New York, U.S.A.) wrote that he concurred with Dr. Peters' preference for smelting over leaching, whenever conditions made the former possible. The greater simplicity of plant and process was overwhelmingly in favour of smelting, and the large size of the cupolas now used, 22 feet by 42 inches or 48 inches, enabled a small plant to do a large amount of work. The Rio Tinto method could be employed, even on suitable pyritic ore, only in a hot climate; and many ores (even though their chemical composition would point to this process as applicable) would not heat up and decompose.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Dr. Peters for his valuable paper.

Mr. J. G. WEEKS seconded the resolution, which was cordially approved.

Prof. AUGUSTE RATEAU'S paper on "The Utilization of Exhaust-steam by the Combined Application of Steam-accumulators and Condensing Turbines" was read as follows:—

THE UTILIZATION OF EXHAUST-STEAM BY THE COMBINED APPLICATION OF STEAM-ACCUMULATORS AND CONDENSING TURBINES.*

By Prof. A. RATEAU.

1. *Introduction.*—The ceaseless march of competition and the continuous rise of costs in these days impel the leaders of industry to seek more actively than ever the means of improving methods of working and processes of manufacture. Within the last few years, extraordinary efforts have been made:—(1) In the direction of concentrating the means of production and the divers industries connected therewith; and (2) in the direction of a more rational and thorough application of scientific method to the purely technical conditions of industry.

In this last order of ideas, the utilization of the heat of fuel, which is still far from having attained its absolute maximum, presents to the inventor's mind an inexhaustible source of possible improvements. Investigation has been especially active along that line, and has indeed been productive of quite remarkable results. In this connection, we may recall the direct use in piston-motors of fuel previously converted to the gaseous condition, and more particularly the utilization in such motors of blast-furnace gases, the calorific power of which had up till that time mostly gone to waste.

Alongside this, the writer may perhaps be allowed to place the economy which he proposes to effect in a whole group of the innumerable appliances of motive power now in existence, by utilizing the enormous quantities of steam daily wasted by intermittently-running engines and exhausting into the atmosphere, such as winding-engines at mines, the reversing-engines of rolling-mills, steam-hammers, etc. One result of the particular conditions, under which these engines must perforce be worked,

* Translated by Mr. L. L. Belinfante, M.Sc.

is that condensation or compounding by the usual methods is more difficult and less efficacious in their case than with ordinary continuously-running engines. Thus it is that the former class of engines has on the whole profited but little by modern improvements in the direction of economy, and thus it is that they continue to lose daily much unapplied energy.

2. *Principle and General Arrangement.*—The system proposed by the writer consists essentially in accumulating in an appropriate apparatus the non-continuous exhaust-steam of intermittently-running engines, so as to obtain from that apparatus a regular flow of steam, which may be subsequently utilized in a secondary engine (preferably a turbine) provided with a condenser.

This arrangement thus enables intermittent engines to take full advantage of condensing arrangements, and to store up mechanically the considerable stock of energy which these engines have hitherto freely exhausted into the surrounding atmosphere.

It is easy enough to demonstrate the theoretical advantage that is to be gained in a general way, by condensing exhaust-steam, that is by pushing to its extreme limits the liberation of steam within any motor. If, in fact, we recall a formula, given elsewhere by the present writer,* for the theoretical consumption of steam in kilogrammes per horsepower-hour, namely:—

$$K = 0{\cdot}85 + \frac{6{\cdot}95 - 0{\cdot}92 \log P}{\log P - \log p},$$

(P being the entrance-pressure of steam and p the exit-pressure in kilogrammes per square centimetre), a formula which may also be expressed as follows:—

$$K = \frac{6{\cdot}95 - 0{\cdot}07 \log P - 0{\cdot}85 \log p}{\log \frac{P}{p}}.$$

We recognize that the last two terms of the numerator being always insignificant in comparison with the first, the theoretical consumption of steam per horsepower is inversely proportional to the logarithm of the ratio P/p of the entrance- and exit-pressures, and that consequently the power produced per kilogramme of steam is sensibly proportional to that logarithm.

* *Rapport au Congrès International de Mécanique appliquée de 1900, sur les Turbines à Vapeur* (report on steam-turbines).

It results from the formula, for example, that the theoretical consumption of an engine, between the pressure P of 6 kilogrammes per square centimetre (85 pounds per square inch), and p of 1 kilogramme per square centimetre (14 pounds per square inch), is equal to 8·8 kilogrammes (19·4 pounds) of steam per horsepower-hour; while the consumption per horsepower would only be 9·3 kilogrammes (20·5 pounds) between the higher atmospheric pressure (P of 1 kilogramme per square centimetre or 14 pounds per square inch) and the lower pressure of 0·15 kilogramme per square centimetre or 2·13 pounds per square inch, which may be produced by an ordinary condenser. We see then that, by applying condensation to steam-engines, the total work theoretically done per kilogramme of steam may be almost doubled. This considerable advantage may now be utilized in intermittently-running engines also, by means of the steam-accumulator and the condensing-turbine.

To utilize the supplementary energy made available by the application of condensation, it was, of course, necessary to transform this energy into mechanical work by means of a suitable engine. And that is the purpose of the steam-turbine, which is introduced between the accumulator and the condenser. The power developed by the turbine is henceforward obtainable without any additional expenditure of fuel, and may be practically reckoned as all gain for working purposes. At all events, its relative value is so great, when compared with the total efficiency of most winding-engines, that the application of the writer's system appears likely to prove a source of considerable profit at those mines or works where it is adopted. We shall see, for instance, that a pit winding 150 tons of coal per hour from a depth of 300 metres (984 feet), may, under these new conditions, utilize an additional force of 500 horsepower hitherto wasted.

3. *Use of the Turbine for utilizing Exhaust-steam.*—It would not be impossible to expand in a piston-motor the regularized jet of steam, but turbines in the case of low-pressure steam offer manifold advantages. It will be easily understood that a piston-engine working at a pressure scarcely equal to that of the atmosphere would involve, in order to utilize properly the entire fall of pressure created by the condenser, dimensions so enormous that the mere cumbrousness of it, not to speak of its weight and

the cost of installation and maintenance, would prove impracticable. Moreover, the efficiency of such an engine would be much inferior to that of a turbine, because of the exaggerated importance of the part played by condensation in cylinders of such huge dimensions; and also because of the inevitable strangulation in the inlets and exhaust-outlets of a steam-jet, the flow of which would be always too abundant (in comparison with the cross-section of the steam-pipes).

On the other hand, the tremendous speed with which steam is ejected in turbines and the resultant great capacity of outflow favour the erection of a turbine capable of utilizing at low pressure a flow of steam of several thousand kilogrammes per hour, while at the same time restricting the size of the apparatus to moderate dimensions. It is noticeable even, and in this practice agrees with theory, that turbines in contradistinction to piston-engines yield on working at low pressures an output slightly greater than that attained with high pressures. Thus, according to the power of the turbine, the output amounts to 60 or 70 per cent. in relation to the theoretical consumption of steam per horsepower-hour,* while the output of a piston-engine working under similar conditions, would hardly exceed 40 per cent. It is well known that the individual output of the low-pressure cylinder of a triple-expansion engine ranges between 35 and 40 per cent., although the cylinder works generally at a pressure exceeding that of the atmosphere.

In other words, if the theoretical consumption of any given engine, working between atmospheric pressure and a pressure at the condenser of 0·15 kilogramme per square centimetre or 2·13 pounds per square inch), amounts, as we have seen, to 9·3 kilogrammes (20·5 pounds) per horsepower-hour, the real consumption will figure out at only (9·3 ÷ 0·65 equals) 14·3 kilogrammes (31·5 pounds) or so per effective horsepower for the turbine, as compared with at least (9·3 ÷ 0·40 equals) 23 kilogrammes (50·7 pounds) for the piston-engine.

There could then be no question of hesitation in making use of the turbine, the more so as it offers in practice a whole series of

* All the figures relating to output in this paper represent the ratio between the work that is actually done and the energy that is theoretically available under such conditions of pressure, so far as the latter can be calculated from the formula set forth on an earlier page. This point should be borne in mind, in case the reader should have occasion to compare the efficiencies stated farther on with the efficiencies usually recorded from piston-engines, which (as a general rule) only express the ratio between the effective work done on the shaft and the work indicated on the pistons.

advantages attaching generally to that type of appliance, namely, maximum compactness, low cost of installation, absence of all complication in erection, working and maintenance, and finally its ideal adaptability to the direct driving of dynamos.

It is only just to say that the Hon. C. A. Parsons, who had contributed more than anyone to the present development of steam-turbines, had also noted, in the course of his experiments, the capability of these appliances for utilizing the lowest pressures of steam and the consequent advantages which might be derived therefrom in practice. The present writer believes, however, that Mr. Parsons' observations in regard to this matter were not followed up by any industrial application. Moreover, Mr. Parsons had in this regard confined himself to the consideration of the direct combination of turbines with piston-engines, with the view of securing more perfect expansion of the motor-fluid. He did not enter into the particularly interesting question, dealt with in this paper, of the utilization of intermittently ejected steam. Moreover, the possible application of turbines to this use could hardly form the subject of serious consideration until engineers had at their disposal appliances capable of regulating the flow of steam (an aim which is attained in the heat-accumulator that the writer is about to describe) and capable of ensuring the complete independence of the second motor in relation to the first. This object also is attained by means of certain complementary arrangements devised by the present writer.

4. *Description of the Apparatus which serves to regulate the Flow of Exhaust-steam.*—The aim which this apparatus was devised to attain will be easily perceived. Let us consider, for instance, the case of winding-engines at mines. These engines only yield steam at the beginning of the wind, finishing it without the aid of steam; then they pause for about ½ minute during the moment when the tubs are being changed. The quantity of steam thus ejected, at each working interval, that is, at the beginning of each wind, often exceeds 150 kilogrammes (330 pounds), or in volume, more than 250 cubic metres (8,800 cubic feet). Now, it is easy to see that an ordinary reservoir, capable of accumulating without too much variation in pressure, so vast a quantity of steam must needs be of huge dimensions; whereas, in the case of

the apparatus to be presently described, both the size and the cost of erection are comparatively moderate.

This apparatus plays the part of an accumulator-regenerator of steam. The solid and liquid substances which it contains form a sort of heat-accumulator, thanks to which, steam, when it flows in abundantly, accumulates, condenses, and is regenerated in the interval during which the flow of exhaust-steam from the winding-engine slackens or ceases. The variations of temperature requisite for the condensation and regeneration of the steam correspond to small fluctuations of pressure in the accumulator. The pressure rises while the apparatus fills, and falls while the latter empties, in response to the turbine.

The amplitude of these oscillations of temperature and pressure is inconsiderable, being 3° to 6° Cent. (6° to 11° Fahr.) for the temperature, and 0·15 to 0·25 kilogramme per square centimetre (2 to 3·5 pounds per square inch) for the pressure. Moreover, this amplitude may be restricted as much as one pleases, provided that in designing the apparatus an ample margin be allowed, according to the periods of activity and repose of the winding-engine.

If we call t the variation of temperature, P, the weight of the substances that form the heat-accumulator; and C, the mean specific heat of these substances; the quantity of heat stored up by the accumulator and given out again at each interval is PCt calories. To these PCt calories corresponds a weight of steam, first condensed, then vaporized, equal to about PCt/L, L being the latent heat of vaporization of water.

The apparatus consists (as will be seen from Figs. 2 and 3, (Plate VIII.), which are respectively a vertical and a transverse section) of a cylindrical sheet-iron cistern, CC, which may be either vertical or horizontal, wherein are piled up, one on top of the other, a series of cast-iron basins, A_1B_1, A_2B_2, $A_n B_n$, of annular shape, made of several pieces so as to facilitate handling. These basins, always nearly full of water, rest one on the top of the other by means of studs, and there are interspaces of a few centimetres (½ inch), so as to allow of the passage of the steam. The result of this arrangement is:—(1) To offer a very considerable surface to the steam both for condensation and revaporization; and (2) to allow of the inclusion, within a small space, of the largest possible mass of metal and liquid.

This mass, which forms a heat-accumulator, should naturally be of greater volume, the greater the quantity of steam that has to be stored and the less the irregularity that appears desirable in the pressure of the exhaust-steam. It may be increased by casting ribs on the bottoms of the basins (*aa*, Fig. 3), and placing therein fragments of iron-scrap and such like material.

The steam, entering the apparatus by a pipe, *D*, passes to the basins by means of the central distributor, *F*. That portion, which remains uncondensed, as well as that which is subsequently revaporized, flows downward along the lateral walls of the cylinder, *CC*, to the outlet-pipe, *E*, which conveys it to the low-pressure engine.

The water, which the particles of steam have carried along with them, separates out in the upper chamber, falling from basin to basin, first of all through holes, pierced in the sheet-iron diaphragm, *TT*, then through the overflow-pipes, *b*, to the bottom of the cylinder, whence it is drawn off by the pipe, *de*, and an automatic steam-trap. As a steam-trap, when the apparatus works at a pressure approximating to that of the atmosphere (which is usually the case), a U tube is employed, forming a reversed siphon.

It will be observed that by the arrangement adopted here, the steam passes through all parts of the apparatus in such a manner that there is no chance of air accumulating anywhere. The necessity is obvious, of preventing any air that is dragged along with the steam, from being localized in some place where it would interfere with the exchange of heat between steam and metal or steam and water.

It might be feared also that the oil, carried along in the steam coming from an engine, the cylinders of which must needs be lubricated, would cling to the metallic surfaces and form an insulating film that would constitute an obstacle to the free interchange of heat. As, however, the duration of the passage of heat is far from being a negligible quantity, and amounts usually to at least ½ minute, the drawback just referred to need not cause much concern. The present writer has, moreover, planned an arrangement whereby the steam enters through the bottom of the accumulator, and is easily rid of the particles of oil and water immediately upon its entrance, so that the basins are kept clear from oil.

5. *Installation of the Apparatus.*—Fig. 4 and 5 (Plate VIII.) illustrate the general arrangement, and represent an apparatus

which has been working at the Bruay collieries (Pas de Calais) since August, 1902.

A is the steam-accumulator, divided in this case into three compartments, into which the steam flows from the winding-engine through a pipe, *V*.

T is the steam-turbine, which receives by means of a pipe, *BC*, the steam coming from the accumulator. This turbine may also be supplied directly with live steam from the boilers by means of a pipe, *H*, whenever the supply from the steam-accumulator proves insufficient. *G* is an automatic valve which admits of the entry of live steam direct from the boilers when needed, without the engineman having to trouble himself about it. It opens when the pressure in the steam-accumulator falls below a given point, which may be fixed at pleasure.

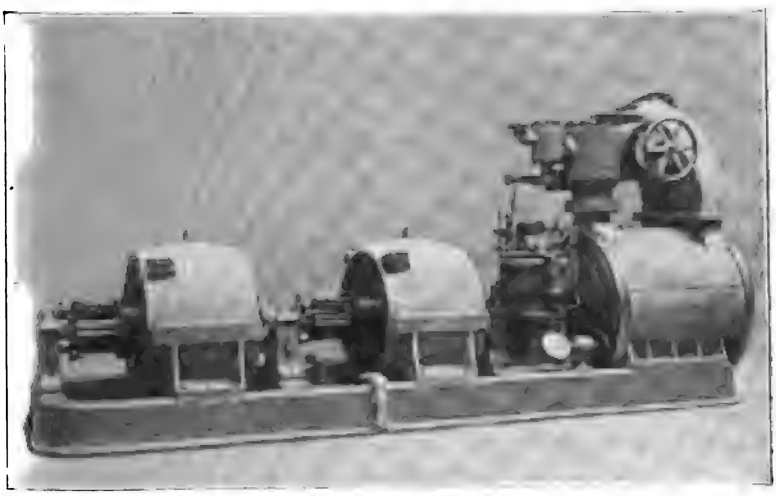


FIG. 1.—RATEAU TURBINE-DYNAMO.

FF are the dynamos coupled directly up to the turbine. They are of continuous-current type, and supply a triplex or three-wire installation. Turbine and dynamos are set up on one and the same cast-iron bed. The exhaust-steam from the turbine is led by a pipe, *E*, to a condenser, whether it be an injection-condenser, or a surface-condenser, or a central condenser (as at Bruay), or even an ejector-condenser.

S is an automatic valve intended to allow of the direct escape into the atmosphere of the steam from the winding-engine when

it is not all utilized by the turbine. The pressure of ejection may be regulated at will by means of a spring that acts on the valve.

A very sensitive regulator, *R*, whereof the component parts may be seen to the left of the turbine, controls the speed in such a way that it does not vary by more than 2 per cent., despite the changes of load and the fluctuations of pressure in the accumulator.

It will be observed that these arrangements ensure the complete mutual independence of the winding-engine and of the turbine. Thus, if the latter does not take all the steam from the former, the winding-engine exhausts directly into the atmosphere by means of the automatic valve, *S*. On the other hand, if, during pauses of more or less duration, the winding-engine does not supply enough steam to the turbine, the latter is supplied direct from the boilers by its own automatic valve, *G*.

One might also arrange for a stop-valve, which would permit of the turbine being cut off from the accumulator when necessary, in such wise that steam could be fed to the turbine from the boilers at as high a pressure as might be needed to perform all the work. The writer is thinking of those cases where condensation being at a standstill, the turbine would have to eject steam at atmospheric pressure and not *in vacuo*.

The entire plant takes but little room. Turbine and dynamo together, of a capacity which may go up to 500 horsepower, can be lodged in a space of 4 metres (13 feet) in length, 1·5 metres (5 feet) in breadth, and 1·7 metres (5½ feet) in height. The steam-accumulator, if the receivers be arranged vertically, occupies a very small area. As a rule, it may be erected out of doors, as there is no need to protect it from the weather. The only precaution in this regard that need be taken is to cover the accumulator with a layer of some insulating material, so as to obviate too rapid radiation of heat from it.

6. *Working of the Apparatus.*—In order that the working of the apparatus herein described may be more clearly understood, the writer has reproduced in Figs. 8, 9, 10, 11 and 12 (Plate IX.), the actual diagrams obtained from the plant working at Bruay collieries by means of a recording pressure-gauge. This indicates in functions of time the pressure of steam within the accumulator.

The abscissa, *AB* (Fig. 8), corresponds to the duration of a complete wind, which at Bruay colliery lasts rather more than 1

minute. During about 18 seconds, that is, from A to C, the winding-engine expends progressively the whole effort of which it is capable for raising the cages. The exhaust-steam meanwhile flows to the accumulator, and the pressure consequently rises therein up to 1·3 or 1·4 kilogrammes per square centimetre or 18·5 or 20 pounds per square inch (absolute pressure). This limit is fixed by the tension, which may, however, be varied by hand, of the spring that controls the valve, S (Fig. 4, Plate VIII.).* If, therefore, more steam comes in than the accumulator can absorb, the excess immediately escapes by means of the valve, S. At C, the engineman shuts off the steam from the winding-engine, which by its impetus continues to raise the cages up to the pit-mouth, when it stops to allow of the changing of the tubs. This working with steam shut off lasts for about 15 seconds, and at B, the engine starts a fresh wind, after a stoppage of about 35 seconds.

As the turbine inhales continuously the steam, which it needs, supplied to it by the accumulator, the pressure in the latter falls so soon as the inflow of exhaust-steam ceases, that is from the point, C, onwards. So long as this decreasing pressure remains below the working pressure of the turbine, the accumulator alone supplies the steam. But if the pressure in the latter threatens to fall below the limiting pressure, the automatic feed-valve, G, which has been regulated accordingly, opens, and supplies the steam that the accumulator (deprived for one reason or another of the main intermittent supply) is momentarily incapable of furnishing. That is what happens every time that the winding-engine is prevented from restarting with sufficient rapidity its periodic wind, and is precisely illustrated in Fig. 9. At E, the feed-valve has begun to come into play, supplying just the pressure needed for the working of the turbine. As, however, it feeds both the turbine and the accumulator, the pressure in the latter rises almost immediately (from E to F) a little above the working-pressure of the turbine. Nay more, at G (Fig. 8) this continuously rising pressure enables the accumulator, the feed-valve closing sharply, to yield up again (from G to H) a little of the live steam which it had just stored up.

* In the experiments, this maximum pressure amounted to 1·4 kilogrammes per square centimetre or 20 pounds per square inch, yielding a total pressure-variation of 0·40 kilogramme, or 5·7 pounds, that is, higher than the variation of 0·25 kilogramme or 3·5 pounds, which has been previously mentioned as the most suitable. But this initial excess-pressure was then needed in order to make up for the comparative inefficiency of the accumulator, as will be explained on a later page.

Then at H, the feed-valve opens again, and finally at I, the winding-engine restarts running.

The writer need hardly point out that it is the right-hand portion of Fig. 8 which illustrates the normal working of the plant, prolonged stoppages of the winding-engine being rather the exception than the rule when a pit is in the full tide of activity.

It will be observed that the appended diagram (Fig. 10) indicates at K and L, two secondary periods of momentary rise in pressure. The first represents the sudden closure of the throttle-valve of the turbine by the governor following on the excessive opening which had at first resulted from the sudden stoppage at C of the flow of steam from the winding-engine. The second period probably has to do with the complicated handling which four-decked cages necessitate; they have to be unloaded in two operations, and involve repeated inflows of steam to the winding-engine.

As to the pressure of the steam at its very entrance to the turbine, this is continuously controlled by the governor, and will therefore depend solely on the amount of work absorbed by the dynamos. Therefore, it will be absolutely independent of the variations of pressure in the accumulator, provided the centrifugal governor be sufficiently sensitive.

Attention may be further directed to the fact that, at those times when the turbine must be necessarily fed with live steam, its consumption per horsepower-hour will evidently exceed that of an ordinary continuously-running engine, under the same conditions, working at the full pressure of the boilers (that is, about 16 kilogrammes or 35 pounds per horsepower-hour instead of 10 to 12 kilogrammes or 22 to 26 pounds).

If the irregularities in the working of the winding-engine are reduced to a minimum, the total duration of the inflows of live steam will be inconsiderable in practice, and the consumption (slightly heightened during those intervals) will not materially affect the final economic result. Yet such will not be always the case, and then the greatest possible economy in the working of the turbine may be ensured under any circumstances, by one or other of the following arrangements.

7. *Expansion-turbine.*—The first consists in adding to the low-pressure apparatus, with which we have been hitherto dealing, a

high-pressure apparatus, the function of which will be to take from the boilers live steam during the stoppages of winding. Meanwhile, the low-pressure turbine will take indifferently either the steam from the accumulator or the exhaust from the other engines, each of these sources of supply predominating in turn.

The two turbines taken together may be considered as an ordinary high-pressure plant capable of receiving at any moment and utilizing in the best way possible the steam ejected from a primary engine. With an ordinary vacuum, the combined apparatus would only consume from 6 to 9 kilogrammes (13 to 20 pounds) of steam per electrical horsepower-hour at full load, if supplied solely with live steam at say 8 kilogrammes per square centimetre (114 pounds per square inch); and, as aforesaid, it would consume from 14 to 18 kilogrammes or 31 to 40 pounds (as the case might be) if supplied solely with exhaust-steam at atmospheric pressure. Of course the inflow of live steam would be arranged automatically according to the power required of the turbine and so as to complete the quantity of low-pressure steam already flowing in.

8. *Raising of the Exhaust-pressure of the Primary Motor.*— The second arrangement admits of a simple solution. It consists in deliberately raising the exhaust-pressure of the winding-engine (by fixing the normal pressure for the accumulator at, say, 3 kilogrammes or 43 pounds per square inch), and in utilizing the regular flow from the last-named in a medium-pressure turbine, working somewhere between 3 kilogrammes or 43 pounds and the lower pressure (0·15 or 0·10 kilogramme or 2 or 1½ pounds) of the condenser. As a rule, the working of the winding-engine will not be much affected by this increase of pressure, while some advantage will be reaped by making up with live steam, under favourable conditions, the full supply of the turbine. The necessity of resorting to a supplementary high-pressure turbine as in the previously described arrangement is also obviated. It is true that the live steam will have to undergo expansion up to 3 kilogrammes per square centimetre or 43 pounds, but this expansion being inconsiderable when compared with that necessitated in the previous case, its disadvantages will be greatly minimized. Thus from P (3 kilogrammes per square centimetre or 43 pounds per square inch) to p (0·15 kilogramme per square

centimetre or 2 pounds per square inch) the consumption will only be 10 kilogrammes or 22 pounds of steam per horsepower-hour, the turbine being fed either with exhaust-steam or with live steam. This result is numerically comparable with those yielded by good compound high-pressure condensing engines.

In the writer's opinion, it would be advisable to resort to the simple arrangement just described when erecting a new winding-engine, for it involves the considerable advantage of utilizing in the fullest possible manner the steam produced by the boilers. It will not have escaped notice, to begin with, than the consumption by the turbine of 10 kilogrammes or 22 pounds per horsepower-hour ensures very fair efficiency. Then, too, the efficiency of the primary engine, in which the steam is used before reaching the turbine, is itself improved by the heightening of the exhaust-pressure, one of the results of this heightening being the limitation of the temperature-interval to the cylinder of the primary engine, and consequently the limitation of condensation in that cylinder.

But, if the output, compared with the ideal engine, be thus improved, the consumption of steam per horsepower-hour of the primary motor is, however, slightly increased. It will, then, be necessary, to obtain the full benefit of this device, that the full stream of steam, which the primary motor is able to supply, or at least the greater part of it, be utilized in the turbine. Yet that supposition will only be fulfilled if the turbine is so designed as to produce at its normal working-speed a sufficient quantity of electric energy.

The arrangement just described might be still further improved by combining it with the preceding one; in other words, by causing live steam to expand, between the boiler-pressure and the pressure at the inflow into the secondary turbine, in a small turbine adjusted to the same shaft.

9. *Condenser.*—The condenser may be of any type. Most often it will be a mixing-condenser provided with an air-pump. It may also be a surface-condenser or else an ejector-condenser, which latter possesses the merit of simplicity. The writer thinks it necessary to observe, however, that in these low-pressure engines there is every advantage in aiming at the best possible vacuum, in view of which the use of surface-condensers, although more costly, appears preferable.

If there be already a central condenser, as was the case at Bruay colliery, it will suffice to interpose the accumulator and the turbine between that condenser and the primary engine.

It is, of course, assumed that the use of condensers implies the supply of sufficient cold water to absorb all the exhaust-steam. But it is quite possible to dispense with renewed supplies of water by using over and over again the same water cooled either in pulverizing sprays in the open air or in cooling-towers.

We know that in the case of mixing-condensers, the quantity of steam given up to the air is sensibly equivalent to, or even less than, the quantity of water re-introduced into the boilers, in such wise that with these condensers the condensation-water, far from being wasted, is regained. In plant of this kind, however, the water never undergoes complete cooling, and so we can only reckon on a comparatively perfect vacuum.

10. *Results which it is possible to obtain by Means of the Rateau System.*—(*a*) *Mines.*—Let us consider first of all the case of the winding-engines at a colliery, taking as an example the actual conditions that obtain at one of the twin shafts at No. 5 pit at Bruay colliery, where the writer's system has been applied. This shaft winds coal from a depth of 230 metres (755 feet), and although it is not yet in full activity, no less than 64 winds per hour have been accomplished, during which time 256 tons of coal and refuse have been brought to the surface. Now, 50 winds per hour constitute the usual average in collieries; with eight-tub cages this is equivalent, when the pit is in full work, to an output of 200 tons or thereabouts. But 200 tons raised through 230 metres (755 feet) necessitate an expenditure of energy represented by 175 horsepower-hours. A similar figure would be arrived at if we were to consider the case of a shaft 310 metres (1,017 feet) deep (which is the average depth obtaining in the Nord and Pas-de-Calais coal-fields) winding 150 tons per hour. On the other hand, we may reckon at 45 kilogrammes or 100 pounds per utilized horsepower-hour the consumption of steam in non-compound winding-engines with free exhaust. Therefore, the consumption of steam of such an engine will amount to about (175 horsepower by 45 kilogrammes or 100 pounds) 8,000 kilogrammes or 17,500 pounds per hour, under normal conditions of working. This is a considerable expenditure, easily explicable,

however, if we reflect that the engine works intermittently and consequently cools down at each stoppage in a way that affects very unfavourably its efficiency or output.

Out of these 8,000 kilogrammes or 17,500 pounds, we may reckon that about 20 per cent. (or say, 1,600 kilogrammes or 3,500 pounds) is lost by various condensations taking place in the pipes and internal parts of the engine. There would then remain available about 6,400 kilogrammes or 14,000 pounds of steam per hour, the complete utilization of which is now ensured by the writer's system.

Since the consumption of a turbine, working between the atmospheric pressure and a pressure in the condenser of (for instance) 0·15 kilogramme or 2 pounds amounts to about 14·5 kilogrammes or 32 pounds per effective horsepower-hour, that is, 16 kilogrammes or 35 pounds per electric horsepower-hour, it follows that the application of the writer's system to a colliery-shaft will entail the production of additional power to the extent of (6,400 ÷ 16 or 14,000 ÷ 35 equals) 400 net electric horsepower-hours.

Such estimates, moreover, are extremely moderate, since the lowering (perfectly feasible in practice) of the lower pressure to 0·10 kilogramme or 1½ pounds (instead of 0·15 kilogramme or 2 pounds) would of itself have the effect of reducing to 13 kilogrammes or 28½ pounds per electric horsepower-hour the steam-consumption of the turbine. Thereby, the additional power obtainable in the aforesaid colliery-shaft would be increased to 490 electric horsepower-hours.*

Nay, more, if we decided to utilize also in the turbines the exhaust-steam of the accessory engines, driving ventilators, air-compressors, etc., before sending it to the condenser, the additional power which could be safely reckoned as available in such a case would no longer be a matter of merely 400 or 500, but often more than 1,000 electric horsepower.

(*b*) *Steelworks.*—If we turn now to the great steelworks, we shall find that it is by no means unusual to see there reversible plate-rolling engines, consuming some 20,000 kilogrammes or

* It will be noted that, at the rate of 13 kilogrammes or 28½ pounds of steam per electric horsepower-hour (a result which can be most certainly attained in practice) the low-pressure electric generator would perform about three times as much useful work as the winding-engine; and at the rate of 18 kilogrammes or 40 pounds, it would still perform about twice as much.

44,000 pounds of steam per hour. From what has been said above, it may be inferred that such an engine could be made to feed a turbine yielding 1,000 effective electric horsepower. And if we supplemented the exhaust-steam of the main engine by that from all the other motors, especially from the steam-hammers, we could obtain from a works of ordinary size consuming about 60,000 kilogrammes or 132,000 pounds of steam per hour, an additional supply of about 3,000 horsepower.

It may be observed, moreover, that this recovery of power would be more simple, more immediate, more certain in its working, and above all less costly than an equivalent recovery by means of the direct utilization of blast-furnace gases.

11. *Adaptation of the Rateau System to Intermittently-running Engines already provided with Condensing Apparatus.*—In cases where the intermittently-running engine is already provided with a condenser, it would still be found advantageous to interpose between the engine and its condenser the proposed group of accumulator-*cum*-turbine. In other words, the advantage derived from the application of the writer's system would far more than compensate the loss entailed by raising the exhaust-pressure of the principal engine so as slightly to increase the consumption of steam. Indeed, the writer has shown, at the very beginning of the present paper, that the application of his system to an intermittent engine allows of the completest possible utilization of the fall of temperature that becomes available on the adjunction of a condenser, and ensures thereby a practical advantage represented in figures by much more than 50 per cent. (in relation to the consumption of steam in intermittently-working engines with free exhaust). Now, experience proves that condensation alone, in that type of engine, fails to reduce their consumption by more than 15 or 20 per cent. Therefore, the writer's system would still ensure, even in those engines already provided with condensers, an additional saving of at least 30 to 35 per cent.

This can be shown also in the following way. Suppose that we are dealing with a primary engine consuming 6,000 kilogrammes or 13,200 pounds of steam per hour, when not working with the condenser. If we apply condensation, the actual saving in practice will be from 15 to 20 per cent., that is, for the same amount of work performed by the engine, condensation will

economize from 900 to 1,200 kilogrammes or 2,000 to 2,650 pounds of steam at boiler-pressure that can be used in another motor. Now, with these 900 to 1,200 kilogrammes or 2,000 to 2,650 pounds of steam a good ordinary condensing piston-motor will develop some 90 to 120 effective horsepower.

With the writer's system of accumulator and steam-turbine, the primary engine will still consume the aforesaid 6,000 kilogrammes or 13,200 pounds of steam per hour; but about 80 per cent. of that amount, say 4,800 kilogrammes or 10,560 pounds of dry steam, will be utilizable in the turbine. This, at the rate of 16 kilogrammes or 35 pounds per horsepower, will give us 300 effective horsepower instead of the 90 to 120 obtained previously. The great advantage to be derived from the new arrangement may be thus accurately gauged.

12. *Saving to be effected by the Proposed System.*—The economy which may be expected to result from this arrangement belongs to two categories:—(1) Saving on the cost of installation of a group of electric-energy generators; and (2) saving on the cost-price of the energy thus furnished in the course of working.

(*a*) *Economy in the Cost of Installation.*—This will arise chiefly from the suppression of the boilers, which it would have been necessary to put down if the writer's system were not adopted, in order to produce the electric energy required for certain auxiliary purposes in the mine. It will arise also from the lower price of the turbine and dynamos and the reduced cost of installation, in comparison with what would be involved by a group of piston-engines of the same power. On the other hand, the saving will be to some extent diminished by the cost of the accumulator and the corresponding pipe-connections, although it is evident that the accumulator will in any case cost less than a range of boilers producing equivalent power.

These different factors will vary considerably in relative importance according to the additional power required, the mass of the accumulator, the system of working of the main engine, and the working conditions generally. It is consequently rather difficult to name definite figures. We may, however, reckon that in order to obtain in a colliery 500 electric horsepower, absorbing about 5,000 kilogrammes or 11,000 pounds of steam per hour, it

would be necessary to expend at least 80,000 francs (£3,200) on boilers; whereas the price of the writer's accumulator, including 75 tons of cast-iron, the needful pipe-connections, and the cost of erection, would hardly exceed 30,000 or 40,000 francs (£1,200 to £1,600). This alone, then, would imply a saving of 40,000 or 50,000 francs (£1,600 to £2,000). On the other hand, to erect a generating-plant actuated by piston-engines (dynamos and cost of installation being included) would involve, at the rate of 225 francs (£9) per horsepower, an expenditure of about 112,500 francs (£4,500). The adoption of the turbine would constitute another probable saving on this of about 30 per cent. (say, 35,000 francs or £1,400). It would seem then that, taken altogether, the saving on the cost of installation of an additional 500 horsepower may (by using the writer's system) amount to as much as 75,000 or 85,000 francs (£3,000 to £3,400), namely, about 30 per cent. compared with an ordinary plant. These, of course, are only rough calculations, but they suffice to demonstrate the absolute certainty of an initial saving on the cost of erecting plant in those cases where the writer's system is adopted.

(*b*) *Economy in the Current-cost of Production of the Additional Power recovered.*—There is no need to compare the total expenditure involved in the production of the additional power by a piston-engine with that by the proposed system, in order to obtain an idea of the enormous saving in the current cost of working. This saving will in greatest measure arise from the suppression of any additional expenditure on fuel, so long as the primary engine is at work. It will also arise from the possibility of dispensing with the firemen who would have had to be engaged if new boilers had been put down, and also from the annual amortization of the 30 per cent. saved on the first cost of installation.

For the same reasons as those assigned on a foregoing page, it is hardly feasible in a general way to express these savings numerically. We may, nevertheless, attempt to form some idea of what they imply in the case (already considered) of a colliery-plant that is to be provided with an additional 500 electric horsepower. The annual economy would then be approximately, on the assumption that the machinery works 10 hours a day:—

	Francs.	£
1. Saving in coal at 2 kilogrammes or 4·4 pounds per horsepower, or 10 tons per diem or 3,000 tons per annum, at 10 francs or 8s. the ton	30,000	1,200
2. Saving in labour: 2 firemen	4,000	160
3. Saving on the amortization in 12 years of the installation, about	7,000	280
Totals	41,000	1,640

It will be noted that the saving here is most considerable on the coal-bill. Consequently the economy thus effected would bulk still greater in the case of steelworks, which generally pay from 15 to 20 francs (12s. to 16s.) per ton for their fuel, while the engines are more numerous, more concentrated, more diverse than those used in collieries, and for the most part are kept working day and night. The annual saving effected on the hypothetical 500 additional horsepower, even if the working day were restricted to 10 hours, would then (in the case of steelworks) amount to 70,000 francs (£2,800) or so.

Finally, we may observe that the annual economy, that of amortization, being deducted, represents, in comparison with the total cost of installation of the system: in the case of a mine, 25 per cent. of the estimate, and in the case of steelworks, more than 40 per cent. In other words, the cost of installation would be gradually extinguished by the sinking-fund which the actual saving on the mere cost of working represents, in the one case in 2½, and in the other in 4 years.

13. *First Results obtained at the Bruay Collieries, Pas de Calais.*—No. 5 pit of the Bruay collieries, at which the apparatus devised by the writer has been erected, has only lately been sunk, and is not yet in full activity. At present, the daily output from this pit ranges from 700 to 800 tons, but it is expected ere long to average 1,200 tons. The consequence is that the winding-engine, with which the writer's accumulator is connected, only works 2 hours *per diem* up to its normal, not to say maximum, capacity. It is, of course, only these periods of regular working that will be considered in the synopsis of results obtained. On the other hand, the electro-turbine plant is just now burdened with a very exacting task, supplying among other things large weight-lifting motors, which involve continual and considerable variations of current. But a few months hence, the conditions will have

altered, for the plant in question will have to supply current to the electric motors actuating the ventilators of No. 5 *ter* pit (now being sunk). These motors will take up about 100 horsepower, and it was indeed mainly with the view of utilizing the current for working the new ventilators that the management decided on erecting the steam-accumulator and turbine.

Despite these rather unfavourable conditions, the accumulator fulfils the expectations formed in regard to it, and the turbine works with satisfactory regularity. In the note appended to this paper will be found a succinct description of the electric plant (turbine and dynamo) erected at Bruay colliery. The turbine, fed by the accumulator, exhausts its steam into a central condenser, which also receives the exhaust-steam from the air-compressing engines and the ventilating engine. It will be shown further that the vacuum yielded by this condenser was at first far from satisfactory, and, consequently, the power produced by the turbine was much less than it would otherwise have been.

With regard to the accumulator, it consists, as was shown on a previous page, of three chambers, and comprizes in all 30 tons of cast-iron distributed over a series of annular and segmented basins, 10 centimetres (4 inches) in height. With this weight of metal, this accumulator is at present a little too weak, as will be seen from the diagrams shewn in Figs. 8, 9, 10, 11 and 12 (Plate IX.) to which we may now direct our attention.

14. *Diagrams of the Pressures in the Accumulator.*—The diagrams of pressures recorded in the Bruay accumulator have already been used in a preceding chapter to show in a general way how the writer's system works. It remains now to study them from the point of view of the particular results yielded in practice by this first installation.

The reader will bear in mind that the graphic curves now referred to were traced out by a Richard recording pressure-gauge; that the pressures are measured along the ordinates, and time-intervals along the abscissæ. The horizontal line, *O*, corresponds to the pressure of the atmosphere, and the intervals between the principal vertical arcs represent each one minute of time.

Fig. 8 was taken at a moment when the winding-engine was

working at normal speed, while the turbine was working at an average inflow-pressure of 0·89 kilogramme or 12·7 pounds per square inch absolute, which corresponds to a calculated* flow of 4,950 kilogrammes or 10,900 pounds of steam per hour; as the vacuum at the condenser did not exceed 56·4 centimetres (22·2 inches) of mercury, the power produced amounted to 198 electric horsepower.

It will be observed in the diagram, that the pressure in the accumulator oscillates between O (atmospheric pressure) and 0·40 kilogramme per square centimetre or 5·7 pounds per square inch, at which point the exhaust-valve opened into the atmosphere. Therefore, the accumulator would suffice to supply the turbine if this maximum variation of 0·40 kilogramme or 5·7 pounds in the pressure were deemed admissible. Yet this cannot be, for so marked a fluctuation is much too excessive, in comparison with that which had been laid down as best satisfying all the conditions of the problem.

Fig. 9 was taken under analogous conditions, though the winding-engine was working somewhat differently towards the end of the record. The period of a wind, instead of being only 1¼ minutes (as at the normal speed recorded in Fig. 8) now amounted to more than 1½ minutes. The accumulator was then no longer equal to the task of regularizing the flow of steam (5,000 kilogrammes or 11,000 pounds per hour) needed by the turbine; and the automatic feed-valve opened at E so as to draw upon the boilers, so soon as the accumulator had been emptied of steam. At each opening of the automatic feed-valve rises in pressure took place, indicated at EF in Fig. 9.

Fig. 10 indicates a load on the turbine equivalent to 115 horsepower, the inflow-pressure amounting only to 0·63 kilogramme per square centimetre or 9 pounds per square inch and the flow of steam to about 3,500 kilogrammes or 7,600 pounds per hour. The curve shows that the accumulator in this case works with far greater ease, and that under such conditions it is quite adequate to supply the turbine even if the wind-intervals last as long as 2 minutes. The vacuum in the condenser was then 57·2 centimetres (22·5 inches) of mercury.

Fig. 11 was taken at a moment when the turbine was only

* This flow was calculated by applying the results previously obtained from experiments in the factory to the conditions of pressure above cited.

producing 85 horsepower, with the same vacuum of 57·2 centimetres (22·5 inches) and with a higher pressure of 0·54 kilogramme or 7·7 pounds corresponding to an hourly flow of steam of 3,000 kilogrammes or 6,550 pounds. The accumulator this time is far more than adequate, and the lower pressure rises to 0·10 kilogramme or 1½ pounds above atmospheric pressure, the upper pressure being determined (as before) by the valve exhausting into the atmosphere, as it did at each wind.

Fig. 12 indicates an analogous consumption of the turbine, the higher pressure being equivalent to 0·60 kilogramme per square centimetre or 8·5 pounds per square inch, vacuum 52 centimetres or 20·5 inches of mercury, and power produced, 65 electric horsepower. It will be noticed that here again the live-steam feed-valve was not called upon to enter into play, although the valve exhausting into the free air had been so adjusted as to open at a pressure only 0·25 kilogramme or 3½ pounds higher than that of the atmosphere.* On the other hand, the valve admitting the live steam had been adjusted so as to let it in only at a pressure slightly less than that of the atmosphere, and this explains the lowering of the minima of the curve below zero.

In all these diagrams a peculiarly rapid rise of the pressure is noticeable at the time when the winding-engine begins to work. In concert with the colliery-engineers the writer, in planning the accumulator, had calculated that the winding-engine would eject steam during about ½ minute (duration of movement of the cages); while in reality, as the graphic record proves, this exhaust only lasts over 15 to 18 seconds. Consequently, the speed at which the steam reached the accumulator was far greater than could have been foreseen, and the apparatus proving rather inadequate, it was found necessary to load the valve which exhausts into the free air, so as to ensure a rise or back-pressure of 0·40 kilogramme or 5·7 pounds per square inch above the atmospheric pressure, instead of the 0·25 or 0·30 kilogramme (3·6 to 4·3 pounds) which had been provided for. It would suffice, however, to add

* The exhaust-valve still allowed a great quantity of steam to escape into the atmosphere, even when the turbine was taking up nearly 5,000 kilogrammes or 11,000 pounds of steam per hour supplied solely by the accumulator, while the automatic steam-trap of the last named was ejecting 1,000 kilogrammes or 2,200 pounds per hour. Hence it may be inferred that the total consumption of an engine like that at Bruay is at normal speed much more than 6,000 kilogrammes or 13,200 pounds per hour.

to the apparatus a fourth unit, which should comprize about 10 tons of cast-iron, in order to reduce the back-pressure to the desired amount.

These same diagrams show also that, after each interruption of the inflow of steam into the accumulator, there is at first a very rapid and then a slower, diminution of pressure. Such variations in the rate of vaporization are evidently due to the fact that the whole mass of cast-iron and water contained in the apparatus does not immediately assume an equilibrium of temperature with the steam. The heat, of course, takes a certain time to penetrate fully into the body of the metal, and the delay thus involved produces a rise and then a fall in pressure, both far more rapid than if a temperature-equilibrium could be set up immediately. It is, however, easy to ascertain by calculation that the greater part of the metal and of the water contained in the basins plays in fact the part of a heat-accumulator.

Figs. 8 and 9 represent, on the whole, the normal working of the turbine, since this had been designed for a higher pressure of 0·90 kilogramme or 12·8 pounds absolute. If the whole system then produced only 200 instead of the 300 horsepower which it is capable of producing, this was entirely due to the unsatisfactory vacuum yielded by the condenser, which only reached 56·4 centimetres (22·2 inches) of mercury, instead of the 65 centimetres (25·6 inches) which had been reckoned with. For with 65 centimetres (25·6 inches) the expected 300 horsepower could certainly be obtained, as the factory experiments prove—whereof an account is appended at the end of this paper.

It may be mentioned also that the variations of the speed of the engine are of greater amplitude than will be admissible in another installation, as here they amount to about 3 per cent. This variation in speed results partly, it is true, from the irregularity of the work which the turbine is called upon to perform. It is evidently due also to the variations of pressure in the accumulator above the turbine. As the pressure oscillates at each interval, that is, about every minute, between 1 and 1·40 kilogrammes or 14 and 20 pounds absolute, we are confronted with much the same result as if the work exacted from the turbine varied from minute to minute by about 30 per cent. As, however, this variation is not excessively rapid, since the rise and fall in pressure each take more than ½ minute to come about, a fairly

sensitive governor has certainly all the time been needed to prevent the speed from varying by more than 2 or even 1 per cent. When the accumulator shall have been supplemented by a third section, and when the difference in pressure becomes only 0·30 instead of 0·40 kilogramme (or 4·3 and 5·7 pounds) the fluctuations in speed of the turbine will be considerably diminished.

It should be added that at No. 5 pit at Bruay, which (as previously stated) has been working for a comparatively short time, the winding-engine on the shaft where the writer's apparatus has been erected is not yet worked up to its normal capacity, since it winds only 700 or 800 tons instead of the 1,200 tons for which it was designed. It follows that, for the moment, the emission of steam is not altogether regular, and the automatic live-steam valve on the turbine calls more frequently and during comparatively longer periods upon the boilers for a supply than would be the case in an older-established colliery. But this state of things will quickly change for the better, *pari passu* with the development of the workings.

To sum up: despite the not very favourable conditions under which the writer's first steam-accumulator must needs work, it has already proved, and proves daily, that the practical and economical utilization of intermittently ejected steam is a problem that has now been solved.

At Bruay colliery, the improvement in the vacuum yielded by the condenser and an increase in the bulk of the heat-accumulator will in the very near future ensure the full advantage that may be expected from this first application. *A fortiori* will this hold good of new installations, for most collieries, from the standpoint which we are occupying, work under far more favourable conditions than No. 5 pit of the Bruay collieries. In steel-works, the circumstances should prove still more favourable.

The writer has thought that it might be of interest to summarize in the appended note a description of the low-pressure turbine and the experimental results obtained at the factory. These results were recorded partly by himself, and partly by Mr. Sauvage and Mr. Picou, in the presence of the engineers of Bruay colliery.

In conclusion, he wishes to express his thanks, first of all to the board of directors of the Bruay colliery and more especially to Mr. Soubeiran (who was confident as to the practical value of the writer's ideas); secondly, to the engineers of Bruay colliery, who took every care in erecting the various portions of this new installation.

APPENDIX.—RESULTS OF THE EXPERIMENTS CARRIED OUT IN APRIL, 1902, ON THE LOW-PRESSURE TURBINE FOR BRUAY COLLIERY, IN THE WORKSHOPS OF MESSRS. SAUTTER-HARLÉ & CIE.

The Bruay turbine, designed and constructed in the workshops of Messrs. Sautter-Harlé & Cie, is a multicellular turbine comprizing a series of wheels, 88 centimetres (34·65 inches) in diameter, adjusted upon one and the same horizontal shaft. These rotate, according to the arrangements that characterize the writer's system, between diaphragms, which are fixed within the cylinder of the engine, and on the periphery of which the distributors are set. The whole thus constitute a consecutive series of turbines with partial injection, which the steam traverses parallel and concentrically to the axis, passing alternately from a crown or ring of fixed blades to a wheel or ring of moving blades, and from this last to the next following distributor.

The working being effected by impulsion, the expansion of the steam takes place only in the successive distributors, while the fluid acts on the moving blades by its *vis viva*. Therefore, each moving wheel rotates within a medium of uniform pressure which allows of considerable play between the blades and the adjacent fixed parts (3 to 5 millimetres, or 0·12 to 0·20 inch). The radial section of the blades and in particular the section of the various distributors increase the farther outward flow of steam and afford continuously wider passage to the fluid in proportion as its pressure and density diminish. The maintenance of a constant speed for variable loads is ensured by means of a ball-governor, which adjusts the higher pressure of the steam supplied to the engine to the power required. This governor is provided with a Denis compensator, which is designed to maintain the speed permanently at a fixed rate. Moreover, the speed may be modified at will between 1,500 and 2,000 revolutions a minute, thanks to a spring the tension of which can be varied by hand. Moreover, an automatic valve is adjusted, so as to admit into the turbine live steam coming direct from the boiler in case the supply of exhaust-steam proves inadequate.

Two continuous-current dynamos, supplying a triplex-wire 500 volts system, are mounted on the same shaft, directly coupled to that of the turbine. They are two-pole dynamos, but are also provided with two supplementary poles so that there may be commutation at the brushes without throwing these out of gear. The induction-coils, series-wound, can each furnish a current of 400 to 450 amperes at a tension of 250 volts.

Fig. 1 is a general view of the machinery, reproduced from a photograph.

The experiments conducted with this turbine lasted in each case about 20 minutes, and allowed of 8 series of observations every 3 minutes. The average or mean results are embodied in Table I.

TABLE I.—EXPERIMENTS WITH THE LOW-PRESSURE TURBINE AND DYNAMO OF 300 HORSEPOWER FOR THE BRUAY COLLIERIES.

No. of Experiment.	Revolutions per Minute. n	Volts. V	Ampères. A	Kilowatts at the Terminals.	Electric Horsepower† at the Terminals.	Absolute Pressures. Steam to Turbine. P Kilogrms. per square centimetre.	Steam to Turbine. P Pounds per sq. inch.	Condenser. p Kilogrms. per square centimetre.	Condenser. p Pounds per sq. inch.	Temperature of Steam. t' Cent.	Temperature of Steam. t' Fahr.	Flow of Steam Measured. I Litres per hour.	Flow of Steam Measured. I Cub. feet per hour.	Consumption of Steam per Horsepower-hour. Measured. K Kilogrs.	Measured. K Pounds.	Theoretical. K Kilogrs.	Theoretical. K Pounds.	Efficiency. ρ*
APRIL 3RD, 1902.																		
1	1,337	471·0	360·0	169·5	230·0	0·845	12·02	0·150	2·13	132	269·6			20·50	45·2	9·95	21·9	0·485
2	1,412	475·0	364·0	173·0	235·0	,,	,,	,,	,,	,,	,,			19·85	43·8	,,	,,	0·501
3	1,500	480·0	368·0	176·5	240·0	,,	,,	0·156	2·22	,,	,,			19·40	42·8	10·05	22·2	0·518
4	1,610	490·0	380·0	186·0	253·0	,,	,,	,,	,,	,,	,,	4,660	165	18·40	40·6	,,	,,	0·547
5	1,690	495·0	385·0	190·5	259·0	,,	,,	,,	,,	,,	,,			18·00	39·7	,,	,,	0·559
6	1,830	503·0	392·0	197·5	268·5	,,	,,	,,	,,	,,	,,			17·40	38·4	,,	,,	0·578
7	1,840	503·0	393·0	198·0	269·0	,,	,,	,,	,,	133	271·4			17·30	38·1	,,	,,	0·581
8	1,510	490·0	460·0	225·0	306·0	1·010	14·37	0·175	2·49	135	275·0			18·60	41·0	9·60	21·2	0·516
9	1,605	500·0	465·0	232·5	316·0	,,	,,	0·177	2·52	,,	,,			18·05	39·8	9·65	21·3	0·534
10	1,700	510·0	472·0	240·5	327·0	,,	,,	0·181	2·57	,,	,,	5,700	201	17·45	38·5	9·75	21·5	0·559
11	1,800	515·0	480·0	247·0	336·0	,,	,,	0·184	2·62	,,	,,			16·95	37·4	9·85	21·7	0·580
APRIL 5TH, 1902: EXPERIMENTS MADE BY MESSRS. SAUVAGE AND PICOU.																		
12	1,610	‡	‡	‡	0·0	0·136	1·94	0·087	1·23	111·4	232·5	570	20	—	—	—	—	0
13	1,608	§	§	§	0·0	0·141	2·00	0·088	1·25	117·0	242·6	—	—	—	—	—	—	0
14	1,589	514·3	136·7	70·3	95·6	0·381	5·42	0·088	1·25	111·0	231·8	2,226	79	23·20	51·1	11·40	25·1	0·492
15	1,600	506·7	278·1	140·9	191·7	0·659	9·37	0·128	1·82	135·0	275·0	3,693	130	19·10	42·1	10·10	22·3	0·530
16	1,591	505·6	399·6	202·0	275·0	0·902	12·83	0·163	2·32	137·0	278·6	5,010	177	18·00	39·7	9·56	21·1	0·531
17	1,598	503·2	462·1	232·5	316·5	1·034	14·70	0·196	2·79	147·0	296·6	5,736	203	17·90	39·5	9·92	21·9	0·556

The barometric pressure was 755 millimetres (29·73 inches) during the first series of experiments, and 760·5 millimetres (29·94 inches) during experiments Nos. 12 to 15; and 759 millimetres (29·88 inches) during the last two experiments.

* The efficiency is the relation between the electric power measured at the terminals of the dynamo, and the theoretical energy contained in the current of steam utilized for such conditions of pressure; this yield is therefore stated after the deduction of all losses in the turbine and in the dynamo.

† A French electric horsepower equals 0·736 kilowatt. ‡ Machine working without excitation. § Excitation of 1,200 watts.

In all the experiments, steam was superheated from 40° to 50° Cent. (104° to 122° Fahr.), in view of the expansion, which it would at first have to undergo in order to be brought down from the pressure at the boilers to a pressure barely equivalent to that of the atmosphere. But the results contained in Table I. have been so calculated as to take this superheating into account, and they must be sensibly equivalent to those obtained when working with saturated steam, which is the ordinary course in practice at Bruay collieries.

It will be seen that the consumption of steam per electric horsepower-hour at full load amounts to about 18 kilogrammes (40 pounds) at 1,600 revolutions per minute, but only to 17 kilogrammes (37½ pounds) at 1,800 revolutions, and that with a bad vacuum of only 63 centimetres (24·8 inches) of mercury. If the vacuum had attained 70 centimetres (27·6 inches), which is quite practicable with a good condenser, the above-stated rates of consumption would have been reduced by about 26 per cent., falling consequently to 13 and 12 kilogrammes (28¼ and 26½ pounds) respectively.

The efficiency at 1,600 revolutions, at full load, of turbine and dynamo taken together, amount to 55 per cent., and at 1,800 revolutions it rose to 58 per cent. The structural conditions involved in the fact that the dynamos had been designed to run at a speed never exceeding 1,800 revolutions per minute, alone prevented the writer from increasing the experimental speed. Nevertheless, the diagram which it is possible to plot out from the foregoing results in functions of the speed, allows us to estimate that at 2,500 revolutions per minute an efficiency of 64 per cent. would be obtainable.* In fact, this has been obtained since then, from a similar group of machinery, but of twice the power, and supplied with high-pressure steam. Fig. 13 (Plate IX.) shows the curve of efficiencies in functions of the speed.

Fig. 14 (Plate IX.) shows the curves of efficiencies at two different speeds in functions of the load, that is, of the electric power produced at the dynamos. It will be observed that the efficiency becomes considerable at one-third load, and on the other hand remains practically unchanged from half-load upwards.

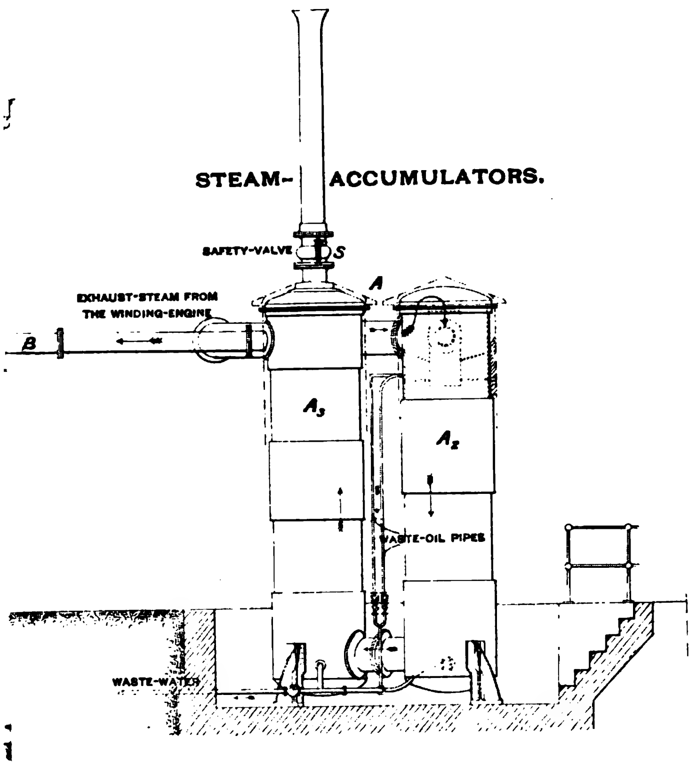
Finally, Fig. 15 (Plate IX.) illustrates the total consumption of steam in functions of the load. It shows clearly that the total consumption at zero load, the electric apparatus being excited, does not exceed 12 per cent. of what it is at full load. With other groups of turbines and dynamos, the writer has known it to fall to 10 per cent. This peculiarity of turbines is worthy of note, for it is known that electrogenerative groups, comprizing piston-engines, consume generally when running at zero load about 20 per cent. of their total consumption at full load.

The Hon. C. A. Parsons (Newcastle-upon-Tyne) wrote that the members were much indebted to Prof. Rateau for bringing this matter prominently before them, as there were, undoubtedly, many cases where such a system would probably lead to a great saving in the consumption of coal, and a reduction in the number of boilers required.

* It is possible then to design when needed, low-pressure plant which shall have an efficiency of 64 per cent. This, between a steam-pressure equivalent to that of the atmosphere and a vacuum-pressure of 0·08 kilogramme or 1 pound, corresponding to a good vacuum of 70 centimetres (27·6 inches) of mercury, would show a consumption of only 11 kilogrammes (24 pounds) of saturated steam per electric horsepower-hour, excitation included.

RATEAU TURBINE OF 300 HORSEPOWER.

–SIDE ELEVATION.



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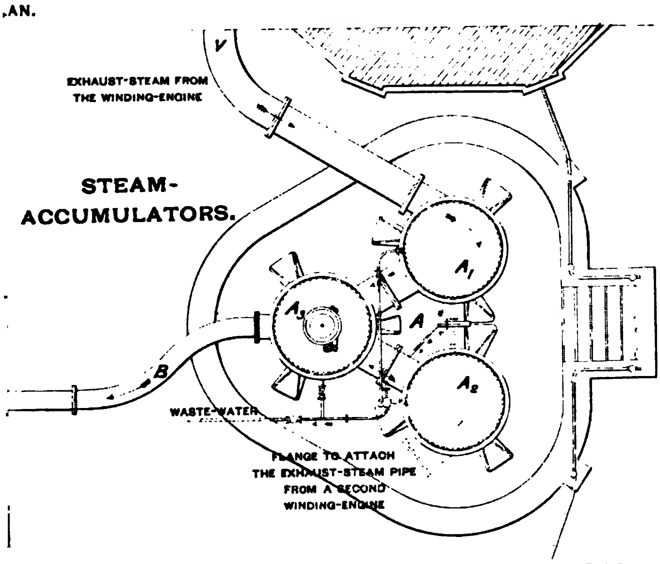

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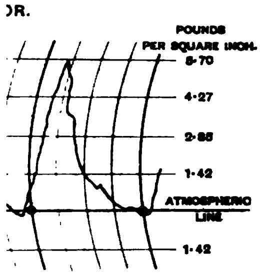
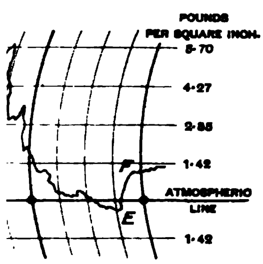
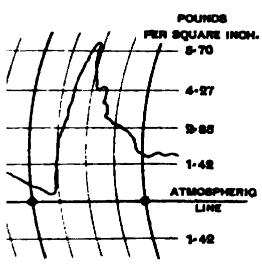
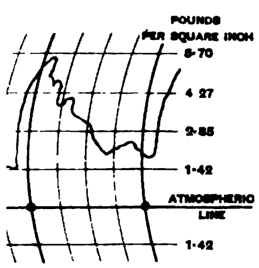








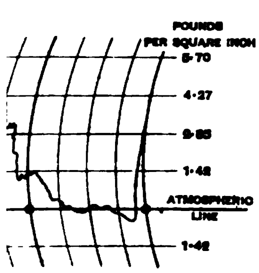


FIG. 13.—TURBINE-DYNAMO OF 300 HORSEPOWER.

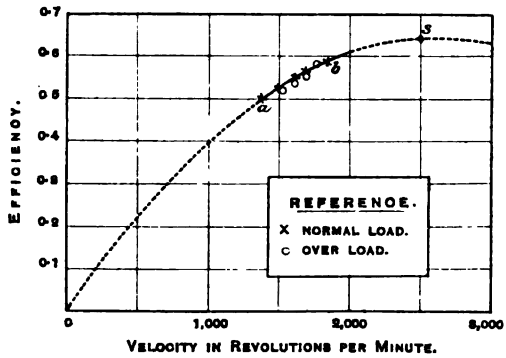


FIG. 14.—TURBINE-DYNAMO OF 300 HORSEPOWER.

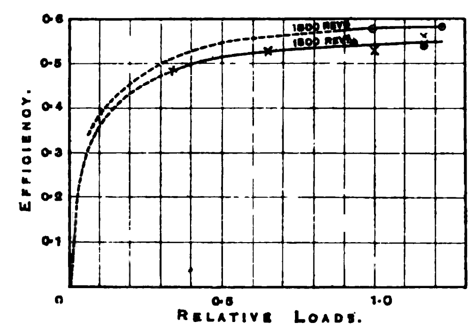
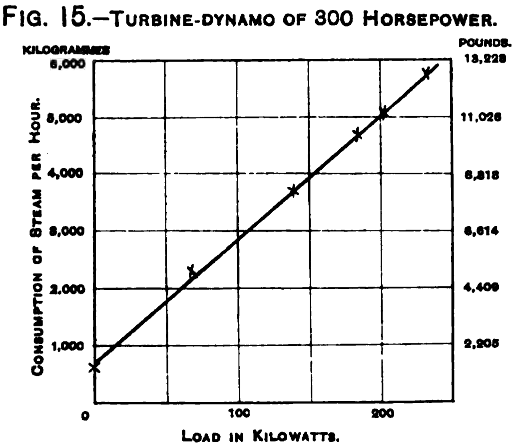


FIG. 15.—TURBINE-DYNAMO OF 300 HORSEPOWER.



It might be interesting to add a short, and perhaps incomplete, history of the initiation and application of the fundamental principle. The first suggestion of the storage of energy by condensing and re-evaporating the water in a chamber, well lagged with non-conducting material, was probably to be found in connection with the hot-water locomotive. Such a system was proposed for the motive power on the Metropolitan Railway in London many years ago. Then there are (previously or subsequently) Mr. Smith Halpin's patents, No. 20,203 of 1891, and No. 363 of 1892, describing and claiming the same principle of the storage of energy in water in conjunction with steam-boilers generally, for dealing economically with a varying load and in particular with reference to electric-lighting generating-stations.

Prof. Rateau, in his interesting paper, proposes to utilise this principle by the storage of energy at or about atmospheric pressure. The formation of his storage-vessel differs somewhat from previous designs, in placing the heating element—the hot water—in shallow trays. The advantage of such an arrangement over that previously adopted, of blowing the steam below the surface of the water, would seem doubtful: in both cases, the result desired was easy condensation, and the tray system appeared to be the more complex of the two. In both cases, the re-evaporation takes place with facility.

The first suggestion, as far as he (Mr. Parsons) was aware, of utilizing the reciprocating engine for the expansion of steam from boiler-pressure, down to a moderate pressure—such as the atmospheric pressure—and completing the expansion in a steam-turbine, occurred in his (Mr. Parsons') patent, No. 367 of 1894:—"The method of obtaining work from expanding steam by combining together a reciprocating-engine and a steam-turbine, the turbine being operated wholly or partially by the exhaust-steam from the reciprocating-engine;" and that patent described many uses for the low-pressure turbine, one of which was for electric lighting.

Prof. Rateau wrote, thanking the Hon. C. A. Parsons for the support which he had kindly accorded to his communication, and expressed his delight at availing himself of the opportunity thus offered to express his due sense of the remarkable ingenuity and high value of Mr. Parsons's various inventions, as also his

appreciation of the originality of the process suggested by Mr. Smith Halpin in 1893, for accumulating heat in central electric generating-stations. But he (Mr. Rateau) was desirous of removing any misunderstanding that might possibly arise in regard to his own invention, which was absolutely independent of the ideas put forward by Mr. Parsons and Mr. Halpin. He (Mr. Rateau) had in his paper referred to the arrangement described by Mr. Parsons, which consisted in using a low-pressure turbine in place of the last cylinder of a continuously-running piston-engine, so as more fully to utilize the expansion of the steam.* In this arrangement, the turbine and the piston-engine are placed in the most intimate association. They form a whole, the parts of which are completely interdependent, and could not therefore work if the primary piston-engine were to run as irregularly as, say, the winding-engine placed on a pit.

By his (Prof. Rateau's) system, however, thanks to the steam-accumulator on the one hand, and to the automatic valve on the other, the primary-engine and the turbine are mutually independent. Each can work separately, without influencing in the slightest degree the working of the other.

The Halpin process consists in accumulating, in hot-water reservoirs, the heat of the excess-steam coming from the boilers at an electric lighting-station during periods of light load, and then in regenerating this excess in the evening when the machinery is running at full load. It constitutes neither more nor less than an indirect means of increasing the total volume of water contained in a set of boilers, and forming a calorific accumulator. These reservoirs, being interposed between the boilers and the high-pressure engines, are evidently not adapted to fulfil his (Prof. Rateau's) object, that of utilizing the exhaust-steam of intermittently-running engines. Mr. Parsons, however, appears to consider that this same apparatus, if interposed between an intermittent high-pressure engine and a low-pressure one, would fulfil all the purposes of his (Prof. Rateau's) accumulator, and that perhaps still more simply. An adaptation of this kind is indeed not impracticable, but it implies essential modifications, as demonstrated in a later arrangement which he had devised. Steam cannot be regenerated so easily within a compact mass of water as within relatively thin films of liquid spread

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 326.

over a great surface; and this applies not so much to the moment at which the steam is reconstituted as to that at which it is condensed. At the period of condensation, the mass forming a heat-accumulator must be made to absorb within a very short space of time (usually 15 to 30 seconds) a vast quantity of calories. This operation cannot be performed efficiently, unless the aforesaid mass is divided into comparatively thin layers; or unless very active circulation of the liquid is ensured, in such wise that the steam shall enter into direct contact with every part of it. The Halpin apparatus, designed for very slow progressive condensation, would certainly not permit of the almost instantaneous condensation of an abundant flow of steam, such as that necessitated by intermittent engines. It does not, therefore, seem to be applicable in practice to the special case which he (Prof. Rateau) has in view.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Prof. Rateau for his valuable contribution to the *Transactions.*

Mr. C. C. LEACH seconded the resolution, which was cordially approved.

THE INSTITUTION OF MINING ENGINEERS.

THIRTEENTH ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, SEPTEMBER 17TH, 1902.

MR. JAMES S. DIXON, RETIRING-PRESIDENT, IN THE CHAIR.

ELECTION OF OFFICERS, 1902-1903.

The SECRETARY announced the election of officers for the ensuing year by the Council as follows:—

PRESIDENT:
SIR. LINDSAY WOOD, BART.

VICE-PRESIDENTS:

Mr. HENRY AITKEN.	MR. M. DEACON.	MR. GEORGE MAY.
SIR LOWTHIAN BELL, BART.	MR. J. T. FORGIE.	MR. H. B. NASH.
MR. G. E. COKE.	MR. JOHN GERRARD.	MR J. B. SIMPSON.
MR. JOHN DAGLISH.	MR. A. MAYON HENSHAW.	MR. J. G. WEEKS.
	MR. R. S. WILLIAMSON.	

AUDITORS:
MESSRS. JOHN G. BENSON AND SON, Newcastle-upon-Tyne.

TREASURERS:
MESSRS. LAMBTON AND COMPANY, The Bank, Newcastle-upon-Tyne.

Mr. J. S. DIXON (Retiring-President) said the time had now arrived when he must retire from the presidency of the Institution, and it was with great pleasure that he vacated the chair in favour of Sir Lindsay Wood, Bart. He had been associated with their new President on the Royal Commission on Coal-supplies, and he had formed a high opinion of his powers for work and detail. He felt assured that he would make an efficient President of the Institution, and it was the second time that he had occupied the position.

Sir LINDSAY WOOD, Bart., in taking the chair, said that his first duty was to propose a vote of thanks to his predecessor for the great trouble that he had taken in the conduct of the affairs of the Institution during his term of office. Although retiring from the Presidency, he felt sure that Mr. J. S. Dixon would still give the members the benefit of his advice and assistance. Mr. Dixon's munificent gift of £10,000 to Glasgow University at the end of last year testified definitely to the great interest that he took in mining, and in the higher education of mining-engineers and others connected with the great mining industries of the country.

Mr. J. B. SIMPSON seconded the vote of thanks, which was cordially adopted.

Mr. J. S. DIXON, in acknowledging the vote of thanks, took the opportunity of thanking the Vice-presidents, the members of the Council and the Secretary of The Institution of Mining Engineers for the manner in which they had supported him during his term of office.

The SECRETARY read the Annual Report of the Council as follows:—

THE INSTITUTION OF MINING ENGINEERS.

THIRTEENTH ANNUAL REPORT OF THE COUNCIL.

The six federated societies constituting The Institution of Mining Engineers are the same as last year, namely the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The following table exhibits the progress of the membership since the formation of the Institution in 1889:—

Year ending July 31st.	No. of Members.	No. of Non-federated.	Totals.
1890	1,189	50	1,239
1891	1,187	9	1,196
1892	1,415	19	1,434
1893	1,533	19	1,552
1894	2,068	123	2,191
1895	2,210	109	2,319
1896	2,301	81	2,382
1897	2,447	60	2,507
1898	2,462	47	2,509
1899	2,445	41	2,486
1900	2,447	35	2,482
1901	2,524	30	2,554
1902	2,571	30	2,601

Messrs. E. Harzé, W. H. Pickering and Fred. A. Grey have been elected Honorary Members of the Institution.

The Institution took charge of Section VI.—Mining and Metallurgy—of the International Engineering Congress held at Glasgow in September, 1901. The members are to be congratulated upon the excellent papers communicated at this meeting, and at that held in London in May, 1902. The thanks of the Institution have been sent to the gentlemen who kindly opened their collieries and works to the members attending these meetings.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xviii, and xix.):—

"Probable Duration of the Scottish Coal-fields." By Mr. R. W. Dron.
"Notes upon Ancient and Modern Surveying, and Surveying Instruments, Books, Tables, etc." By Mr. H. D. Hoskold.
"The Rating of Coal-mines." By Mr. G. Humphreys-Davies.
"Subsidences in and around the Town of Northwich, Cheshire." By Mr. Thomas Ward.

Addresses have been delivered during the year by Sir William Thomas Lewis, Bart., and Mr. James S. Dixon, presidents of The Institution of Mining Engineers; by Mr. G. E. Coke, president of The Midland Counties Institution of Engineers; by Mr. Henry Aitken, president of The Mining Institute of Scotland; by Prof. Charles Lapworth, president of the South Staffordshire and East Worcestershire Institute of Mining Engineers; and by Mr. James Mansergh, president of the International Engineering Congress, Glasgow, 1901.

The high standard of the papers published in the *Transactions* has been maintained, and the Council trust that papers will be contributed as liberally as heretofore.

The papers on geology include the following:—

"Slips in a Sandbank." By Mr. James Barrowman.
"The Carboniferous Limestone Coal-fields of West Lothian." By Mr. Henry M. Cadell.
"The Oilshale-fields of the Lothians." By Mr. Henry M. Cadell.
"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse.
"The Coal-field of Northern Belgium." By Mr. É. Harzé.
"The Sequence of the Carboniferous Rocks in North Staffordshire." By Dr. Wheelton Hind.
"Lead- and Zinc-deposits of the Mississippi Valley, U.S.A." By Messrs. C. R. Van Hise and H. Foster Bain.
"Deposits of Hydroborate of Lime: Its Exploitation and Refination." By Mr. Carlos A. Lynes Hoskold.
"The Dysart, Wemyss and Leven Coal-field, Fifeshire." By Mr. Richard Kirkby.
"Note on a Mineral Vein in Wearmouth Colliery." By Prof. Henry Louis.
"Mineral Resources of the Province of Quebec, Canada." By Mr. J. Obalski, H.M. Inspector of Mines.
"The Rand Conglomerates, Transvaal." By Mr. Hugh Pearson.
"The Belvoir Iron-ore." By Mr. R. F. Percy.
"The Coal-fields of New Brunswick, Canada." By Mr. Henry S. Poole.
"The Tarquah Gold-field, Gold Coast, West Africa." By Mr. A. R. Sawyer.
"The Tarkwa Gold-field, West Africa." By Mr. A. R. Sawyer.
"The Buffelsdoorn and Adjacent Districts of the Northern Klerksdorp Gold-fields, Transvaal." By Mr. William Smith.
"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson.

"Recent Work in the Correlation of the Measures of the Pottery Coal-field of North Staffordshire, with Suggestions for further Development." By Mr. John T. Stobbs.

Mining engineering has been discussed in the following papers:—

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr. Thomas Arnott.

"Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales." By Mr. A. A. Atkinson, H.M. Inspector of Mines.

"Description of Underground Haulage at Mossblown Colliery, Ayrshire." By Mr. James Baird.

"What is the least possible Waste in Working Coal?" By Mr. James Barrowman.

"Unwatering and Fitting a Lanarkshire Colliery with Modern Appliances." By Mr. Robert Broom.

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"A Method of Working the Thick Coal-seam in two Sections." By Mr. William Charlton.

"Coal-mining in India." By Mr. R. W. Clarke.

"Sinking by Freezing." By Mr. A. Gobert.

"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.

"Mining and Treatment of Copper-ore at the Wallaroo and Moonta Mines, South Australia." By Mr. H. Lipson Hancock.

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr. John Hogg.

"The Dysart, Wemyss and Leven Coal-field, Fifeshire." By Mr. Richard Kirkby.

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr. Thomas Moodie.

"Boring in Japan." By Mr. F. J. Norman.

"The Re-opening of Hartley Colliery." By Mr. R. E. Ornsby.

"Gold-dredging in Otago, New Zealand." By Mr. F. W. Payne.

"The Belvoir Iron-ore." By Mr. R. F. Percy.

"Chinese Mines and Miners." By Mr. Alexander Reid.

"The Tarquah Gold-field, Gold Coast, West Africa." By Mr. A. R. Sawyer.

"The Tarkwa Gold-field, West Africa." By Mr. A. R. Sawyer.

"The Buffelsdoorn and Adjacent Districts of the Northern Klerksdorp Gold-fields, Transvaal." By Mr. William Smith.

"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson.

"Auriferous Gravels and Hydraulic Mining." By Mr. William S. Welton.

"Tapping Drowned Workings at Wheatley Hill Colliery." By Mr. W. B. Wilson, Jun.

Mechanical engineering has been the subject of the following papers:—

"A Method of Socketing a Winding-rope, and its Attachment to a Cage without the Use of Ordinary Chains." By Mr. W. C. Blackett.

"The B.C.B. Instantaneous Either-side Brake for Railway Wagons and Similar Vehicles." By Mr. Edward Brown.

"Newcomen Engines." By Mr. M. Walton Brown.

"An Instrument for the Automatic Record of Winding Operations." By Mr. Walter Newton Drew.

"Fitting a New Drum-shaft to a Winding-engine, Florence Colliery, Longton." By Mr. C. V. Gould.

"Some Experiences and Results derived from the Use of highly Superheated Steam in Engines." By Mr. R. Lenke.

"Changing Headgears at Pleasley Colliery." By Mr. G. A. Longden.

"A Regenerative Steam-accumulator, and its Application for Using Exhaust-steam." By Prof. A. Rateau.

The following papers have been contributed on mine-ventilation and safety-appliances:—

"An Apparatus for Lighting Miners' Safety or other Enclosed Lamps by Electric Current." By Mr. Edward Brown.

"Experiments on an Auxiliary Ventilating Fan." By Mr. M. Walton Brown.

"Experimental Gallery for Testing Life-saving Apparatus." By Mr. W. E. Garforth.

"A New Diagram of the Work of Mine-ventilation." By Mr. H. W G. Halbaum.

"Apparatus for Closing the Top of the Upcast-shaft at Woodhorn Colliery." By Mr. C. Liddell.

"Remarks on Mr. M. Walton Brown's Report on 'Mechanical Ventilators.'" By Prof. A. Rateau.

Mine-surveying and instruments have been treated of in the following papers:—

"A Traversing Stand for a Theodolite."

"The Grubb Sight for Surveying-instruments." By Sir Howard Grubb and Mr. Henry Davis.

"A New Civil and Mining Engineers' Transit-theodolite for Connecting Underground Workings to the Surface, *vice-versa*, and for General Surveying." By Mr. H. D. Hoskold.

"Standardization of Surveyors' Chains." By Prof. Henry Louis.

"Mine-surveying Instruments." By Mr. Dunbar D. Scott.

"The Connection of Underground and Surface Surveys." By Mr. G. R. Thompson.

The following papers have been written on metallurgy, etc.:

"A Native Lead-smelting Furnace, Mexico." By Mr. A. H. Bromly.

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"The Imperfect Pulverization of Rocks by means of Stamping, and Suggestions for its Improvement." By Mr. E. D. Chester.

"Crucible-assaying of Gold-ores." By Mr. Hamilton C. Dickson.
"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.
"Mining and Treatment of Copper-ore at the Wallaroo and Moonta Mines, South Australia." By Mr. H. Lipson Hancock.
"Deposits of Hydroborate of Lime: Its Exploitation and Refination." By Mr. Carlos A. Lynes Hoskold.
"Treatment of Low-grade Copper-ores in Australia." By Mr. J. J. Muir.

The application of electricity has been discussed in the following papers:—

"An Apparatus for Lighting Miners' Safety or other Enclosed Lamps by Electric Current." By Mr. Edward Brown.
"The Economy of Electricity as a Motive Power on Railways at present driven by Steam." By Prof. C. A. Carus-Wilson.
"Mechanical Undercutting in Cape Colony." By Mr. John Colley.
"Electric Traction on Roads and Mineral Railways." By Mr. W. R. Cooper.
"Electric Pumping-plant at South Durham Colliery." By Mr. Fenwick Darling.
"The Practical Results obtained on Changing the Motive Power of an Underground Pump from Steam to Electricity." By Mr. Hugh P. Swann.
"Sparkless Electric Plant for Use in Mines and Ironworks." By Mr. J. H. Whittaker.

The question of coal-cutting has been the subject of the following papers:—

"Coal-cutting by Machinery." By Mr. R. W. Clarke.
"Mechanical Undercutting in Cape Colony." By Mr. John Colley.
"The Application of Coal-cutting Machines to Deep Mining." By Mr. W. E. Garforth.

Coal-washing has been the subject of the following papers:—

"Campbell Coal-washing Table." By Mr. Clarence R. Claghorn.
"The Craig Coal-washer." By Mr. William Scott.

The following papers have been contributed on the subject of coke-making:—

"Coke-making at the Oliver Coke-works." By Mr. Fred C. Keighley.
"The Production of Illuminating-gas from Coke-ovens." By Dr. F. Schniewind.

The following memoirs have been communicated:—

"Obituary of Thomas William Jeffcock." By Mr. Oscar J. Cotterell.
"Memoir of the late George Baker Forster." By Mr. R. H. Forster.
"Memoir of the late George Clementson Greenwell." By Mr. G. C. Greenwell.

The miscellaneous papers include:—

"Brick-making." By Mr. George L. Allen.
"Barometer, Thermometer, etc., Readings for the Year 1901." By Mr. M. Walton Brown.
"Legislation and the Ownership of Properties Containing Coal." By Mr. Daniel Jones.
"The Kitson System of Petroleum Incandescent Light." By Mr. Arthur Kitson.
"The Analytical Valuation of Gas-coals." By Mr. G. P. Lishman.
"Report of the Delegate of The Institution of Mining Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Glasgow, September, 1901." By Prof. Henry Louis.
"Coal-mining Subsidences in Relation to Sewerage-works." By Mr. F. W. Mager.
"Report of the Delegate of the North of England Institute of Mining and Mechanical Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Glasgow, September, 1901." By Mr. J. H. Merivale.
"A Visit to the Simplon Tunnel: The Works and Workmen." By Dr. Thomas Oliver.
"The Determination of the Calorific Power of Fuel." By Mr. S. L. Thacker.
"The Training of Industrial Leaders." By Prof. J. Wertheimer.

The preceding list, comprizing 94 papers, demonstrates the varied nature of the subjects printed in the *Transactions* (vols. xxii. and xxiii.) during the past year.

"Notes of Papers (115) on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications" have been continued, and should prove of value to the members.

Members can purchase, at privileged prices, copies of the *Transactions* of the following Corresponding Societies:—

The Australasian Institute of Mining Engineers.
The Canadian Mining Institute.
The Institution of Mining and Metallurgy.
The Mining Society of Nova Scotia.

Prof. H. Louis represented the Institution at the meetings of the Corresponding Societies Committee of the British Association for the Advancement of Science, held at Glasgow, in September, 1901; Mr. John Gerrard at the Jubilee proceedings of Owens College, Manchester; and Messrs. James Barrowman and M. Walton Brown on the London Committee of the International Engineering Congress held at Glasgow.

Since 1852, the date of the formation of the North of England Institute of Mining and Mechanical Engineers, considerable improvements have been adopted in methods of mining and metallurgical processes, accompanied by increased production of minerals and metals, and a decreased death-rate. A great part of these improvements is due to the development of societies devoted to the consideration of methods for the safe working of mines and the preservation of human life. And since that date the means of education for mining-engineers has been enhanced by courses of lectures provided at Universities and Technical Colleges; and examinations have been instituted for mine-manager's certificates. Mechanical appliances for getting minerals and improved explosives have become a necessity, ventilation is produced by fans on the surface instead of by underground furnaces, mechanical haulage has replaced horses, machine-holing is taking the place of human labour, and electricity has been introduced as a motive power for all classes of machinery.

The object of a technical society is not wholly attained unless there be adequate and critical discussion of the papers printed in the *Transactions*. Discussion is the test of the value of a paper, it makes known the experience of the speakers, and it directs attention to questions that may have been overlooked by the writer. The value of the *Transactions* would also be considerably increased by the addition of written remarks, sent to the Secretary, from members who are unable to attend the meetings.

The Local Institutes in Account with The Institution of Mining Engineers, for the Year Ending July 31st, 1902.

Dr.

Dr.	No. of Members: Federated.	No. of Members: Non-Federated.	Balance due at the beginning of the year. £ s. d.	Amounts falling due during the year: Calls made during the year. £ s. d.	Excerpts. £ s. d.	Transactions, etc. £ s. d.	Totals. £ s. d.
Midland Counties Institution of Engineers	316	...	15 4 0	300 4 0	1 5 2	16 6 8	332 19 10
Midland Institute of Mining, Civil and Mechanical Engineers	297	...	10 10 0	282 3 0	4 1 9	4 6 8	301 1 5
Mining Institute of Scotland	415	30	2 3 2	409 5 0	20 0 2	3 6 8	434 15 0
North of England Institute of Mining and Mechanical Engineers	1,215	...	70 6 0	1,154 5 0	20 7 6	29 11 8	1,274 10 2
North Staffordshire Institute of Mining and Mechanical Engineers	212	...	17 19 4	201 8 0	7 11 2	7 6 8	234 5 2
South Staffordshire and East Worcestershire Institute of Mining Engineers...	101	...	53 4 4	95 19 0	0 15 2	6 6 8	156 5 2
Totals	2,556	30	169 6 10	2,443 4 0	54 0 11	67 5 0	2,733 16 9

Cr.

Cr.	Balance from previous year. £ s. d.	Amounts paid during the year: Calls. £ s. d.	Excerpts. £ s. d.	Transactions, etc. £ s. d.	Totals. £ s. d.	Balance due at July 31st, 1902. £ s. d.
Midland Counties Institution of Engineers	15 4 0	285 0 0	1 5 2	16 6 8	317 15 10	15 4 0
Midland Institute of Mining, Civil and Mechanical Engineers	10 10 0	275 10 0	4 1 9	4 6 8	294 8 5	6 13 0
Mining Institute of Scotland	2 3 2	397 17 0	20 0 2	3 6 8	423 7 0	11 8 0
North of England Institute of Mining and Mechanical Engineers	70 6 0	1,084 18 0	20 7 6	26 11 8	1,202 3 2	72 7 0
North Staffordshire Institute of Mining and Mechanical Engineers	17 19 4	186 4 0	7 11 2	2 0 0	213 14 6	20 10 8
South Staffordshire and East Worcestershire Institute of Mining Engineers	38 0 4	47 10 0	...	...	85 10 4	70 14 10
Totals	154 2 10	2,276 19 0	53 5 9	52 11 8	2,536 19 8	196 17 6

Dr. THE TREASURER IN ACCOUNT WITH
FOR THE YEAR

	£	s.	d.	£	s.	d.
July 31, 1901.						
To Balance at Bank, Current Account	338	19	3			
„ „ „ Deposit Account	1,019	14	6			
„ „ in Cashier's hands	53	6	7			
				1,412	0	4
To Subscriptions for the Year ending July 31, 1901—						
Federated—						
Midland Counties Institution of Engineers	15	4	0			
Midland Institute of Mining, Civil and Mechanical Engineers	9	10	0			
Mining Institute of Scotland	0	19	0			
North of England Institute of Mining and Mechanical Engineers	70	6	0			
North Staffordshire Institute of Mining and Mechanical Engineers	12	7	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	31	7	0			
				139	13	0
To Subscriptions for the Year ending July 31, 1902—						
Federated—						
Midland Counties Institution of Engineers	285	0	0			
Midland Institute of Mining, Civil and Mechanical Engineers	275	10	0			
Mining Institute of Scotland	382	17	0			
North of England Institute of Mining and Mechanical Engineers	1,084	18	0			
North Staffordshire Institute of Mining and Mechanical Engineers	186	4	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	47	10	0			
				2,261	19	0
Non-Federated—						
Mining Institute of Scotland				15	0	0
Carried forward				£3,828	12	4

THE INSTITUTION OF MINING ENGINEERS. **Cr.**

ENDING JULY 31, 1902.

	£ s. d.	£ s. d.	£ s. d.	£ s. d.
July 31, 1902.				
By Printing—				
Transactions, vol. xx., printing ...	197 5 11			
„ „ „ plates ...	122 8 6			
		319 14 5		
„ „ xxi., printing ...	87 19 0			
„ „ „ plates ...	74 13 0			
		162 12 0		
„ „ xxii., printing ...	424 2 5			
„ „ „ plates ...	151 0 3			
		575 2 8		
„ „ xxiii., printing...	72 8 2			
„ „ „ plates ...	44 4 1			
		116 12 3		
			1,174 1 4	
Excerpts, vol. xix.		0 10 6		
„ „ xx.		21 19 6		
„ „ xxi.		19 5 10		
„ „ xxii.		47 8 2		
„ „ xxiii.		11 6 7		
			100 10 7	
Proofs of Papers for General Meetings			23 15 4	
Circulars			17 10 8	
				1,315 17 11
„ Addressing *Transactions*, etc.			40 6 2	
„ Stamps—Circulars		14 13 0		
„ „ Correspondence		20 13 1		
„ „ *Transactions*		349 19 8		
			385 5 9	
„ Stationery, etc.			57 8 1	
„ Insurance of *Transactions*			3 0 0	
„ Binding—Library		3 14 11		
„ „ Sundries		2 15 0		
„ „ *Transactions*		0 5 3		
			15 2	
„ Reporting General Meetings			21 13 6	
„ Expenses of General Meetings			5 4 9	
„ Incidental Expenses			15 0 6	
„ Salaries, Wages, Auditing, etc.			565 15 0	
„ Indexing *Transactions*			27 10 0	
„ Travelling Expenses			61 17 11	
				1,189 16 10
Carried forward				£2,505 14 9

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			3,828 12 4
To Local Publications and Authors' Copies—	1900-1901.	1901-1902.	
The Institution of Mining Engineers... ...	0 0 0	56 9 4	
Midland Counties Institution of Engineers ...	0 0 0	1 5 2	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	4 1 9	
Mining Institute of Scotland	0 17 6	20 0 2	
North of England Institute of Mining and Mechanical Engineers	0 0 0	20 7 6	
North Staffordshire Institute of Mining and Mechanical Engineers	0 19 0	7 11 2	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 0 0	0 0 0	
	1 16 6	109 15 1	
			111 11 7
To Sales of Transactions, etc.—	1900-1901.	1901-1902.	
The Institution of Mining Engineers	0 5 0	177 8 6	
Midland Counties Institution of Engineers ...	0 0 0	16 6 8	
Midland Institute of Mining, Civil and Mechanical Engineers	1 0 0	4 6 8	
Mining Institute of Scotland	0 6 8	3 6 8	
North of England Institute of Mining and Mechanical Engineers	0 0 0	26 11 8	
North Staffordshire Institute of Mining and Mechanical Engineers	4 13 4	2 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 13 4	0 0 0	
	12 18 4	230 0 2	
			242 18 6
To Advertizements			581 11 10
To Address Labels			3 12 6
To Interest on Deposit Account			25 3 11
			£4,793 10 8

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

			£ s. d.
Brought forward		......	2,505 14 9
By Advertizement Commission		......	145 7 11
„ Translations of Papers		3 7 6	
„ Abstracts of Foreign Papers, vol. xx. ...	£12 6 5		
„ „ „ „ xxi. ...	5 0 0		
		17 6 5	
„ Barometer Readings, etc.		5 5 0	
„ Calendars		13 13 6	
„ Prizes for Papers in Volumes xviii. and xix.		20 0 0	
			59 12 5
			2,710 15 1
„ Balance at Bank, Current Account		487 11 1	
„ „ „ Deposit Account		1,544 18 5	
„ .. in Cashier's hands		50 6 1	
			2,082 15 7
			£4,793 10 8

We have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne,
August 7th, 1902.

THE INSTITUTION OF
BALANCE SHEET.—

Liabilities.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements paid in Advance	21	11	8			
Printing, etc.	1,458	0	0			
Postage of Transactions	240	0	0			
Abstracts of Foreign Papers in Volumes xxi., xxii. and xxiii.	150	0	0			
Barometer Readings	8	0	0			
Prizes for Papers in Volumes xx., xxi., xxii. and xxiii.	40	0	0			
Indexing Volumes xxi., xxii. and xxiii.	40	0	0			
Advertizement Commission, etc.	93	7	9			
				2,050	19	5
Balance of Assets over Liabilities				628	9	10
				£2,679	9	3

We have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in our opinion it exhibits a correct view of the affairs of the Institution.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne,
March 6th, 1903.

MINING ENGINEERS.
JULY 31, 1902.

Assets.

	£	s.	d.	£	s.	d.
Balance at Bank, Current Account	487	11	1			
" " Deposit Account	1,544	18	5			
" in Cashier's hands	50	6	1			
				2,082	15	7
Subscriptions for the Year ending July 31, 1901, Unpaid—						
South Staffordshire and East Worcestershire Institute of Mining Engineers	......			15	4	0
Subscriptions for the Year ending July 31, 1902, Unpaid—						
Federated—						
Midland Counties Institution of Engineers	15	4	0			
Midland Institute of Mining, Civil and Mechanical Engineers	6	13	0			
Mining Institute of Scotland	11	8	0			
North of England Institute of Mining and Mechanical Engineers	69	7	0			
North Staffordshire Institute of Mining and Mechanical Engineers	15	4	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	48	9	0			
				166	5	0
Local Publications and Authors' Copies, Unpaid—						
South Staffordshire and East Worcestershire Institute of Mining Engineers	......			0	15	2
Transactions Sold, Unpaid—						
The Institution of Mining Engineers	4	13	6			
North of England Institute of Mining and Mechanical Engineers	3	0	0			
North Staffordshire Institute of Mining and Mechanical Engineers	5	6	8			
South Staffordshire and East Worcestershire Institute of Mining Engineers	6	6	8			
				19	6	10
Advertizements, Unpaid				395	2	8
				£2,679	9	3

BOOKS, ETC., ADDED TO THE LIBRARY.

African Review, London. Vol. xxviii., Nos. 461 and 462; vol. xxix., Nos. 463-475; vol. xxx., Nos. 476-488; vol. xxxi., Nos. 489-501; and vol. xxxii., Nos. 502-511.

Annales des Mines de Belgique, Bruxelles. Vol. vi., No. 4; and vol. vii., Nos. 1-3.

Australasian Institute of Mining Engineers, Melbourne. Transactions, vol. viii., No. 1.

British Association for the Advancement of Science, London. Report of the Seventy-first Meeting, held at Glasgow, in September, 1901. Demy octavo, cxx., 900 and 114 pages.

British Society of Mining Students, Medomsley. Journal, vol. xxiv., Nos. 1-6.

Chemical and Metallurgical Society of South Africa, Johannesburg. Journal, vol. ii., No. 9; and vol. iii., Nos. 1 and 2.

Cory Brothers & Company, Limited, Cardiff. British Coal and Freight Circular and General Export List, August 31st, 1901, to July 31st, 1902.

Engineering and Mining Journal, New York City. Vol. lxxii., Nos. 10-26; vol. lxxiii., Nos. 1-26; and vol. lxxiv., Nos. 1-8.

Engineering Times, London. Vol. vi., Nos. 3-6; vol. vii., Nos. 1-6; and vol. viii., Nos. 1-3.

Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, vol. clii., Nos. 4-6; vol. cliii., Nos. 1-6; and vol. cliv., Nos. 1 and 2.

Institution of Mining and Metallurgy, London. Transactions, vol. ix.

Manchester Geological Society, Manchester. Transactions, vol. xxvii., Nos. 6-9.

Massachusetts Institute of Technology, Society of Arts, Boston. Technology Quarterly, vol. xiv., Nos. 3 and 4; and vol. xv., Nos. 1 and 2.

New South Wales, Department of Mines, Sydney. Annual Report, 1900.

—, Geological Survey, Sydney. Handbook to the Mining and Geological Museum, Sydney, with Special Reference to the Mineralogical Collections, by George W. Card. Demy octavo, 201 pages.

—, —, —. Memoirs, Geological Series, No. 2.

—, —, —. Mineral Resources, Nos. 9 and 10.

—, —, —. Records, vol. vii., No. 2.

New Zealand, Department of Mines, Wellington. Annual Report, 1901.

—, —, —. Report of the Royal Commission appointed to Inquire and Report on the Working of the Coal-mines of New Zealand, 1901. Foolscap folio, 339 pages.

Queensland, Department of Mines, Brisbane. Annual Reports, 1900 and 1901.

—, Registrar-general's Department, Brisbane. The Queensland Official Year-book, 1901. Demy octavo. 425 pages.

Queensland Government Mining Journal, Brisbane. Vol. ii., Nos. 15-19; and vol. iii., Nos. 20-25.

South Wales Institute of Engineers, Cardiff. Transactions, vol. xxii., Nos. 5-8.

United States, Geological Survey, Washington. Annual Report, 1899-1900, parts i., ii., iii., iv., v. (with volume of maps), vi., vi. continued, and vii.

—, —, —. Reconnaissance in the Cape Nome and Norton Bay Regions, Alaska, in 1900, by Alfred H. Brooks, George B. Richardson, Arthur J. Collier and Walter C. Mendenhall. Imperial octavo, 22 pages.

—, —, —. The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, by Frank Charles Schrader and Arthur Coe Spencer. Imperial octavo, 94 pages.

Victoria, Department of Mines, Melbourne. The Gold-fields of Victoria, Monthly Returns, July, 1901, to March, 1902.

Walker, Sydney F. Coal-cutting by Machinery in the United Kingdom. Excerpt from the *Colliery Guardian*. Crown quarto 144 pages.

EXCHANGES.

Annales des Mines de Belgique.
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
*Canadian Mining Institute.
Chemical and Metallurgical Society of South Africa.
Franklin Institute of the State of Pennsylvania, U.S.A.
*Geological Institution of the University of Upsala, Sweden.
*Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
Manchester Geological Society.
Massachusetts Institute of Technology.
*Mining Society of Nova Scotia, Canada.
*Natal, Geological Survey of the Colony of.
New South Wales, Department of Mines and Agriculture, Geological Survey.
*Revue Universelle des Mines, de la Métallurgie, etc.
South Wales Institute of Engineers.
*Transvaal, Department of the Mining Commissioner.
United States Geological Survey.

* No publications received during current year.

July 31*st*, 1902.

The meeting then divided into two sections for the reading and discussion of papers. Sir Lindsay Wood, Bart., presided over one section, and Mr. J. S. Dixon over the other section of the members.

Prof. G. A. Lebour's paper on "The Marl-slate and Yellow Sands of Northumberland and Durham," was read as follows:—

THE MARL-SLATE AND YELLOW SANDS OF NORTHUMBERLAND AND DURHAM.

By Prof. G. A. LEBOUR, M.A., M.Sc., F.G.S.

The Permian rocks—or, to speak more cautiously, the r
which are newer than the Carboniferous and older than the Tri
in the North-east of England possess many peculiarities w
distinguish them from deposits of the same age in the Midla
and which differentiate them still more from those of Westı
land and Cumberland. Much controversy has from time to t
taken place as to the true limits of that system, both upper
lower, in this region. Recently, moreover, a great deal of car
geological work, official as well as non-official, has shown—esp
ally in the central coal-fields of England—that much of the for
tions formerly regarded as Permian has no right to the title,
belongs to the Coal-measure division of the Carboniferous.
appears to the writer, therefore, that it may be useful to
stock of the present state of our knowledge respecting those
tions of the rocks in question which occur beneath the main m
of the system as it is developed in Northumberland and Durh
and constitute, in fact, its basement-beds.

The "main mass" of the Permian referred to in the last p
graph is, of course, the Magnesian Limestone, a very fit sub
for discussion, but one which, in the present paper, it is prop
to touch upon, only in so far as it must be considered in conne
with the beds which, normally, lie beneath it. These beds
the Marl-slate and the Yellow Sands, and their general posi
in the geological series is best expressed in tabular form
follows:—

Permian:
  Magnesian Limestone.
  Marl-slate.
  Yellow Sands.
  ———————— (Unconformity).
Carboniferous:
  Coal-measures.

The Yellow Sands.—In former days, the individuality of this very peculiar deposit was most unfortunately, but very naturally, misunderstood. It was so frequently seen lying upon red or mottled sandstone, the appearance of which was decidedly Permian, that the two were looked upon as a single group and the Yellow Sands merely as its upper part. This view was the more readily entertained as it enabled a close correspondence to be recognized between that portion of the stratigraphical column in England and in Germany. Thus the following erroneous correlation was adopted:—

Magnesian Limestone	... ...	Zechstein.
Marl-slate	.. ..	Kupferschiefer.
Yellow Sands ... Red Sandstone ...	Lower New Red Sandstone ...	Rothliegendes.

It is true that it was, almost from the first, noted that the plant-remains which were found in the Red Sandstone were such as are also found in the Coal-measures, and not in any way characteristically Permian. This point was, however, made light of, and regarded as an indication that the physical break between the Carboniferous and Permian was one of no great importance.

As the country became more and more accurately surveyed, it became at last clear that though the Yellow Sands were, when present at all, always in the same stratigraphical position, that is, beneath the Marl-slate, this was not the case with the Red Sandstone. The latter, in fact, was at last seen to be beneath instead of above the denuded surface-plane upon which rocks newer than the Coal-measures had been piled up. Their un-Permian flora was thus explained, since these red beds were in truth themselves of Coal-measure age. Moreover, their apparent conformity with the overlying deposits was found to be entirely deceptive. Although the beds next below the Yellow Sands were usually red or mottled, it was by degrees proved that they were only here and there, and accidentally, in parallel stratification with the sands, and that almost as frequently they lay beneath them with discordant dips. It follows that they are not, as at first seemed obvious, always the same strata, but represent various horizons of the Coal-measures which assume a red or mottled colour generally increasing in intensity as they approach the plane of erosion. A strong, perhaps the strongest, confirmation of this view is, that of the many faults which dislocate the Coal-measures in the

Permian area of Durham the greater number affect these stained beds and leave the overlying sands unbroken. The Red Sandstone division may now, therefore, be dismissed from the Permian system altogether, though it probably will be long before all text-book writers, many of whom seem doomed to perpetuate error, will realize this.

The Floor.—The floor then, upon which the Permian rocks of the North-eastern counties rest, is a surface of erosion paved by the stained edges of denuded Carboniferous rocks. What that surface was like at the beginning of Permian times can be inferred more or less satisfactorily: (1) By considering the form of the land beyond the present Permian outcrop, where it is not covered by Glacial Drift and later superficial deposits, and allowing for the additional, and often profound, sculpturing which it has undergone since the removal of its Permian covering; and (2) by investigating the unaltered contours of that surface as it remains at the present day, buried beneath the Permian series of rocks.

The first line of investigation is of indirect value only. The evidence to be examined is so meagre, so much has been obliterated. Yet it leads to the belief—confirmed in other ways—that the floor formed a broad sloping plain of quite low gradient and but slightly undulating, reaching from what is now the Permian outcrop to somewhere between the 1,000 feet and the 1,500 feet contours on the eastern flank of the Pennine heights.

The second method gives results of certainty so far as they go, but these results are only attainable by borings and sinkings. Every record of a sinking or boring through the junction between the Permian rocks and the beds beneath them, like a sounding in the ocean, yields a truthful item or datum towards the construction of a contoured map of this ancient floor. The number of such sections is scarcely large enough to enable us yet to draw up a very full chart of this kind, but their number is increasing yearly, and, with the aid of the invaluable volumes of *Borings and Sinkings* published by the North of England Institute of Mining and Mechanical Engineers, the attempt is well worth the attention of some of the younger and more leisured members. At any rate, such information as is obtainable in this way tends to prove that the floor is simply a continuation of the one inferred above as once existing to the west, namely:—A gently sloping surface with

no hills or dales of any size, though not by any means perfectly plane, and dipping gradually beneath the present bed of the North Sea.

The Physical Break in Terms of Time.—It is necessary to pause here in order to draw attention to the meaning, in geological chronology, of the gap in the succession of deposits represented by this floor of erosion or unconformity, in order that its importance may be gauged. In years, or centuries, or tens of centuries, we cannot guess what it represents, but a brief enumeration can be made of some of the more notable events which undoubtedly took place during that time-gap. Briefly they are as follows:—

(1) That portion of the Coal-measures, which now is no longer present, was deposited bed by bed and seam by seam. How many feet of rock this may have been we do not know, but as there is every reason to suppose that there are, in this district, none of the beds known in some other coal-fields as the Upper Coal-measures,* the thickness is probably great.

(2) The broad, flat and enormously thick series of Carboniferous rocks having been completed, vast earth-movements occurred in the form of great parallel anticlinal folds with intervening synclinals, one set running approximately north and south (of which the Pennine saddle or "backbone" is one of the best standing witnesses) and another approximately east and west. The uppermost Carboniferous beds—the Coal-measures—were thus deformed into alternate domes and depressions. Faulting accompanied this folding.

(3) All the upper strata were exposed to long-continued denudation which, with greater or less regularity, removed huge portions of the rocks forming the domes above mentioned, eroding them in places so as to uncover rocks even earlier than the Lower Carboniferous, and smaller portions of the more protected beds in the hollows, the remains of which are our present coal-fields.

When the denudation last referred to had reached the point at which the Coal-measures that are now covered by younger rocks still stand, the earliest deposits of the next system, the Permian, began to accumulate upon the floor prepared for them by these various phenomena, denudation going on, however, as

* Though, as a matter of convenience, it is the custom to call the beds, from the High Main seam upward, by that name.

it has gone on ever since, wherever no such deposits were forming, as in the higher ground along the Pennine ridge, for instance.

The first deposit thus to accumulate was the one known as the Yellow Sands. It is a most peculiar rock. As its name denotes it is a sandy mass, the grains of which are often so loosely held together as to crumble in the fingers, often, however, cemented together by carbonate of lime, sometimes almost as compact and coherent as a typical grit or sandstone. But it is not gritty in the true sense; that is, its grains are not angular bits of quartz bounded by irregular or conchoidal fractures. The grains, which are of moderate size, often quite coarse, are almost invariably well rounded. They are exactly similar to grains of desert sand, wind-worn and unprotected from attrition by a film of moisture such as helps to preserve the sand-grains of a sea-bottom or of a beach. Then the Yellow Sands are false-bedded in the highest degree, and false-bedded exactly in the manner exhibited by sections in the dunes of deserts. They contain no fossils, or at least none which may not have been derived from earlier formations, such as fragments of Coal-measure plants. They are probably nowhere much more than 100 feet or so in thickness, often only a few feet thick and sometimes altogether wanting. They fill up the shallow depressions of the denudation-surface on which they lie, and their base-line necessarily follows the irregularities of that surface. Here and there, as has already been said, the bed is a cemented and fairly compact stone, but the writer believes that this state is merely due to the local leaching downwards of carbonate of lime from the thick overlying limestones, and that the loose type is the normal state of the Yellow Sands. Indeed, were it not for its unsuitability as regards the exceptionally coherent portion of the deposit, the term "quicksands" might very well be applied to the whole formation as, indeed, it is in Yorkshire and Nottinghamshire. The upper surface of the Sands is much more regular than the bottom, although the great variations in thickness and occasional absence of the bed have led many to suppose that the very opposite of this is the case. The state of things as regards the mode of occurrence of the deposit and its relations to the rocks above and beneath will be best understood by a glance at Fig. 1, which is

meant to represent an ideal section parallel with the strike of the Permian strata.

It appears to the writer that the claim of the Yellow Sands to be regarded as the basement-bed of the Permian, where they occur, is exactly analogous to that of the conglomerate, which (in Ribblesdale and along the Pennine escarpment) lies on the edges of the denuded Silurian and Ordovician rocks and beneath the Mountain Limestone, to be considered the basement-bed of the Carboniferous in those regions.

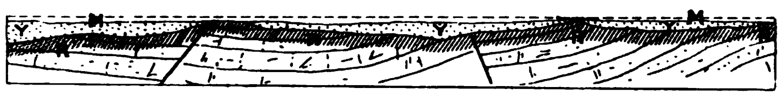


FIG. 1.—References: R, Stained Coal-measures, the Red Sandstone of early writers; Y, Yellow Sands; R and Y together represent the Rothliegendes of early writers; and M, Marl-slate.

As to the nature of their origin, it is perhaps allowable to differ. The late Sir Andrew C. Ramsay in 1871 wrote:—"The Yellow Sands at the base of the limestone-beds are generally a residue of sand. The limestone, which is often sandy, rests on shale, which is comparatively impermeable to water. The limestone dips east; the carbonate of lime has been carried away in solution as bicarbonate; and the sand remains."* It is sufficient to state, in opposition to this view, that the grains of sand which are sometimes present in the Magnesian Limestone are quite unlike those of the Yellow Sands in character, and that where such grains are most plentiful they yet form so very small a percentage of the limestone that a bed such as that now being dealt with would, if a residue, represent a vanished mass of limestone greater than all that is left in the overlying divisions of the Permian—so great as to be scarcely conceivable. In 1890, the late Mr. R. Howse, than whom none was more familiar with the question, suggested that the deposit "may have been an Eolian accumulation of sand . . . . before the Magnesian Limestone began to be thrown down,"† and with this view the present writer is disposed to agree. If this windblown mode of accumu-

* "On the Red Rocks of England of Older Date than the Trias," *Quarterly Journal of the Geological Society of London*, 1871, vol. xxvii., page 245.

† "Catalogue of the Local Fossils in the Museum of Natural History," by Mr. Richard Howse, *Natural History Transactions of Northumberland, Durham and Newcastle-upon-Tyne*, 1890, vol. x., page 252.

lation be the true one, it follows that only imperfect conformity is to be expected between the sands and the Marl-slate, and here again the facts are in accord with the theory.

As the Yellow Sands are now seen, there are some marked features which are obviously of later origin than the sands themselves. These are especially the results of the segregation of carbonate of lime, when that happens to be abundant, in thick or thin irregular anastomosing veins or ribs such as those so strikingly exhibited in Cullercoats Bay, and in more or less spherical concretions such as are also common in the same place and elsewhere. If a fragment of one of these ribs or of one of the concretionary knobs is suspended in a vessel full of acidulated water, the cementing calcium carbonate soon dissolves away and the rounded grains of quartz are freed and fall to the bottom. The veins or ribs play, in places, a rather important and not, the writer believes, a very generally recognized part in connexion with the flow of water through the Sands.

So loosely compacted a deposit, lying as this one does between rocks of much closer texture, is naturally water-bearing in the highest degree, and this property has long been turned to useful purpose for water-supply. Its utility is, however, counterbalanced by its evil consequences in mining operations. It has more than once been noticed that the flow of water—into borings, for instance, or into galleries driven to tap the water—has been considerably less than the extent and thickness of the water-holding bed had led one to expect. It is the opinion of the writer that this is sometimes due to the presence of ribs such as those above referred to. Where they are abundant they tend to form obstructions to the natural flow of the water within the bed and, locally, to separate the latter into more or less completely dammed-in compartments or chambers. When one such reservoir has been pumped dry, or partly so, its refilling from the adjoining water-holding sandy cisterns is impeded, according as the ribs forming its walls act as perfect barriers to the circulation, or, as is more usually the case, only as partial barriers through which the water is filtered but slowly. Several cases of anomalous water-supply failures, or semi-failures, can be accounted for in this way.

Another point connected with the Yellow Sands as a water-bed is deserving of mention and is, the writer thinks, new and of

some importance as regards the present enquiry, inasmuch as it may help to explain some of the irregularities of thickness which are among their most remarkable characters. It is this: Wherever the Yellow Sands crop out at the foot of an escarpment of Magnesian Limestone (their usual mode of occurrence at the surface) and where this outcrop is not completely covered up, and consequently sealed, by Boulder Clay, natural springs issue. The writer has noticed that where such springs have been long undisturbed and where the Sands from which they issue are of the incoherent or quicksand type, there occurs below the spring-mouth under favourable conditions quite a small flattish "cone of dejection" of sand which has obviously been brought by the spring current from within the rock. In most cases, of course, such sand is removed to lower ground by streams, but by careful observation it can be shown that a considerable amount of sand has in the course of time been carried away from its original stratum, though no doubt at irregular intervals. In this way, then, it is thought that the subterranean erosion which has gone on for so long must have extensively altered the distribution of the sand within the beds. From this it follows that, as some of the matter is removed from the lower portions of the Sands, these must, here and there, become less able to support the upper layers of the deposits which may thus in time be let down as well, occasionally, as portions of the overlying Marl-slate or Magnesian Limestone.* Some of the inequalities observed in certain localities at the base of the Marl-slate may, therefore, be due to agencies at work long after the deposition of that stratum and, consequently, be no evidence of original discordance of stratification between that formation and the Yellow Sands. For it should be clearly understood that though the Sands and the Marl-slate each lie upon a floor which is sometimes very uneven, yet the nature of the junction is essentially different. The Sands are thickest in the hollows of their floor, but the Marl-slate is not thicker where the surface upon which it lies is a depression than elsewhere. As the late W. Hutton remarked, many years ago, of a section then visible in Rough Dean, Houghton-le-Spring, the slaty limestone (or the

* For accounts of similar action in drift-deposits, see Prof. G. A. Lebour, *Natural History Transactions of Northumberland, Durham and Newcastle-upon-Tyne*, 1893, vol. xi. page 191; and Blake's *Annals of British Geology for 1893*, pages iii. and 12; and Mr. Wm. Shone, *Quarterly Journal of the Geological Society of London*, 1892, vol. xlviii., page 96; and *Geological Magazine*, 1893, decade 3, vol. x., page 323.

Marl-slate) is there seen "resting upon the Sand, sometimes in a very uneven line, the limestone appearing to bend round and conform itself, to the inequalities of the Sand."* Figs. 2 and 3 explain what is meant. The basins holding the sands were, in fact, in all cases pre-existent; those holding the Marl-slate are many of them subsequent to its deposition. That it is advisable to lay stress upon this point is proved by the inability which some authors have shown to distinguish between the great unconformity at the base of the Sands and the merely apparent or "contemporaneous" unconformity between them and the Marl-slate.†

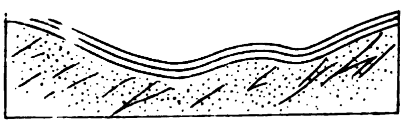


FIG. 2.—DIAGRAM SHEWING THE MARL-SLATE ADAPTING ITSELF TO THE IRREGULARITIES OF THE FLOOR BENEATH IT.

Before leaving the Yellow Sands, it may be useful to give some analyses showing their chemical composition, as that composition has a notable bearing upon the question of the origin of the Sands and of the cause of the staining of the Red Beds beneath them. The analyses are selected, from a number published in 1866, by Messrs. Browell and Kirkby, so as to exhibit the great variation in the percentage of carbonate of lime which may exist in the sands in even neighbouring localities. A is a more solid variety, owing to the amount of calcareous cementing-matter present, B is of the more usual incoherent kind; and both are from Ryhope colliery.

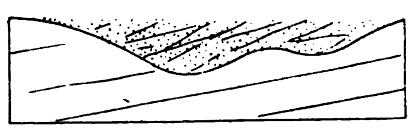


FIG. 3.—DIAGRAM SHEWING THE SAND FILLING THE IRREGULARITIES OF THE FLOOR BENEATH IT.

* "Notes on the New Red Sandstone of the County of Durham below the Magnesian Limestone," by Mr. Wm. Hutton, *Transactions of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne*, 1830-1831, vol. i., page 65.

† "The Permian Formation in the North-east of England," by Mr E. Wilson, *Midland Naturalist*, 1881, pages 97-101, 121-124, 187-191, 201-208. Referring to the Quicksand division of the Permian, it will surprise Durham miners to find Mr. Wilson saying: "It is not certain that this rock is present in Durham. The unconsolidated sand-rocks that are so frequently seen beneath the Magnesian Limestone in that county are now properly classed with the Carboniferous system. It is doubtful whether it has been met with in any of the colliery-shafts, sunk through the limestone" (page 101); and again, speaking of the Marl-slate, he says: "The rapid fluctuations of these beds are evidently owing to their resting on an uneven floor of Carboniferous rocks." It is curious to note that Mr. Wilson has quite clearly realized the Permian age of the "Quicksands" of Yorkshire, where they are far less markedly developed than they are in Durham.

	A.	B.
Carbonate of lime	20·48	0·39
Carbonate of magnesia	1·52	—
Oxide of iron and alumina ..	6·16	10·20
Silica, soluble in dilute acid ...	0·16	—
Sand, clay, etc.	72·88	89·33
Water	—	0·47

In some cases, the iron oxide is as low as 1·28 per cent.*

The Marl Slate.—Already a good deal has been said respecting this early calcareous member of the Permian, in considering its usual precursor—the Yellow Sands. The general mode of junction between the two beds has been explained. It must now be added that there are other modes displayed in certain localities. At Tynemouth, for instance, the Marl-slate is separated from the sands by a bed of massive Magnesian Limestone of the same character as that above, on which the Priory stands. At Cullercoats, a few thin beds of Magnesian Limestone occur in the uppermost portion of the Yellow Sands heralding the Marl-slate, as it were. At Claxheugh, the " Slate " suddenly comes to an end at the eastern extremity of the exposure, and its place is taken by massive Magnesian Limestone.† These three sections exhibit the less usual relations of the two deposits.

On the whole, the Marl-slate may be described as a thin and, considering its thinness, a remarkably persistent and characteristic set of flaggy greyish, bluish, brownish, sometimes even blackish limestones and shales equally distinct from the Magnesian Limestone on the one hand and from the Yellow Sands on the other. It is certainly a marine deposit, since it contains such shells as *Nautilus Freieslebeni*, *Lingula Credneri*, *Discina Konincki*, and *Myalina Hausmanni*, that is to say a Cephalopod, Brachiopods, and a Lamellibranch, but these fossils are exceedingly scarce, and in the same beds have been found several kinds of remains of land-plants imperfectly preserved, such as *Neuropteris Huttoniana*, *Caulopteris (?) selaginoides*, and *Polysyphonia (?) Sternbergiana*. It is clear that, though the beds were formed in sea-water, they were formed by no means far from land, and probably at or very near the mouth or estuary of a river, or the mouths

* *Natural History Transactions of Northumberland and Durham*, 1866, vol i., pages 206 and 207.

† An excellent explanation of the well-known but always puzzling section at Claxheugh has been given by Mr. David Woolacott, in the *Quarterly Journal of the Geological Society of London*, 1898, vol. liv., page 14.

of several streams bringing down the fern-fronds and other vegetable débris from the Pennine high ground.

But the chief peculiarity of the Marl-slate is the large number of extraordinarily complete and well preserved fishes which it has yielded. Moreover, these fishes are of kinds which leave us in doubt as to whether they lived in salt-water or in fresh-water. They belong to such genera as *Palæoniscus*, *Pygopterus*, *Acrolepis*, *Cœlacanthus*, *Platysomus*, the nearest existing rare analogues of which now inhabit rivers and lakes. Together with these are the remains of amphibia such as *Lepidotosaurus*, and of some true reptiles such as *Proterosaurus*. We have thus a fauna which is the reverse of frankly marine, and at the same time not entirely fluviatile or lacustrine. The only reasonable inference seems to be that this fauna is of an estuarine or lagunal kind; that is, existed close to land where the water was probably brackish, where flooded rivers brought down creatures from purely inland waters to become mixed with others belonging to the marginal regions of the sea.

It has been mentioned that the fish-remains are singularly perfect. It is also noticeable that most individuals, as Mr. William Hutton, who first made the observation, wrote "are contorted: not that sort of twisting which might be produced by any movement in the mass, and subsequent to the time they were enveloped, but the graceful contortions of the living animal in a state of pain, as if struggling against its fate." Whether one agrees or not with Mr. Hutton in regarding these petrified convulsions as graceful, it must be admitted that his conclusion that the death of these fishes seems to have been due to some sudden catastrophe is a reasonable one since "it is a generally received opinion, that where the remains of soft-bodied animals occur, with their outward form perfectly preserved, and associated in families [groups], they have been suddenly overwhelmed, and entangled in the substance forming their stony matrix."* Such a sudden overwhelming is a likely one under estuarine conditions, or in lagoons fringing the land, where occasional inroads of abnormal tides might cause destruction among the fresh-water or even brackish-water creatures involved in them.

It has been stated above that the Marl-slate is in some places preceded by earlier calcareous beds, and that sometimes even there

* *Op. jam cit.*, page 71.

is an alternation of sands and limestone-bands beneath the Slate. In such cases we have, in fact, an actual passage from the Sands to the Slate, so that there is, at such places, not even the appearance of unconformity between the two. There is, further, rare but positive evidence of the sandy conditions not having everywhere come to an end before the deposition of the Marl-slate.

In the local notes, which follow, will be found a case or two where a bed of sand occurs above the Yellow Sands. Such evidence should be conclusive as to the close connexion between the Sands and the great Magnesian Limestone of the Permian, of which the Slate is but the usual first stage.

The history of the beginnings of the Permian system in Northumberland and Durham, such as it can be gathered from the facts already stated and from the details with which this paper concludes, seems fairly obvious.

(1) A mass of sand, probably chiefly derived from the waste of the Carboniferous Sandstones which formed so large an area of the then land-surface to the west, occupied a broad tract of coast from somewhere to the north of Hartley, in Northumberland, to Yorkshire and still farther south, narrower in the north than in the south. This sand was a beach at the coast-line and a desert of blowing dunes elsewhere. Rivers, sluggish and probably inconstant (changing their course as do the channels in a delta) wound their way to the sea across this sandy tract, and added to the irregularities of its surface.* The deposition of calcareous and magnesian mud in the thinly bedded layers which betoken tranquil deposition followed, due partly to silting from landwards and from tidal irruptions from sea-wards most probably in a chain of coastal lagoons. This was accompanied by a downward movement of the coast-line and the gradual merging of the lagoons into the sea proper when the Magnesian Limestone, with its curious fauna—a marine fauna checked in its existence by the unfavourable chemical composition of the Permian sea-water to which the rock owes its dolomitic character—was deposited. This view is

* The late Prof. A. H. Green was of opinion that the Quicksands (that is, our Yellow Sands) are the deltas of the streams which emptied themselves into the inland sea. *Geological Magazine*, 1872, vol. ix., page 101. The entire absence of fossil-remains, the form of the grains, and the nature of the cross-bedding seem to point rather to wind as the final distributor of the sand, though Prof. Green's view may quite well be accepted for their first accumulation.

strongly confirmed by the occasional exceptions to the rule that the Marl-slate precedes the Magnesian Limestone proper which have already been referred to, such exceptions (where limestone occurs beneath the Slate) being obviously the result of local accidental breaches of the bars separating the lagoons from the sea.

A number of detailed thicknesses of the beds dealt with in this paper, together with other notes, are given in the Appendix. Such a list would have been impossible before the publication of the admirable *Borings and Sinkings* by the North of England Institute of Mining and Mechanical Engineers. Much difficulty has in many cases been experienced in identifying the beds described in the accounts of borings (sinkings are necessarily much better evidence) and in some of these cases the author has ventured to disagree with previous interpretations. Where the strata are visible to the day he has visited the localities himself, usually many times, and he would wish to take this opportunity of acknowledging the great assistance which was given him in these examinations by the Rev. John Dunn, D.C.L., in the middle eighties.

No doubt in the interpretations in the Appendix some errors must have been committed, and if the publication of such a list elicits accurate information, it will have served its end. The occurrence of water, even in large quantities, at the Permo-Carboniferous junction is, by itself, no guide. There may be much water and no Yellow Sands, and, though much more rarely, the converse may be true. The late Mr. S. C. Crone pointed out long ago that the Sands held more water to the north and east than to the south and west.

Among the papers which should be consulted by all wishing to go more fully into the palæontological and other details of the Marl-slate than has been attempted here, those by Prof. Sedgwick, Mr. Richard Howse, Mr. Kirkby and Dr. William King hold the first place, and very little has been done since their time.

APPENDIX.—THICKNESS AND OTHER PARTICULARS OF THE MARL-SLATE AND YELLOW SANDS FROM NORTH TO SOUTH IN NORTHUMBERLAND AND DURHAM. *Nota Bene.*—Numbers given thus (vol. ii., page 132) refer to the volume and page of the *Borings and Sinkings*, where the full sections are to be found.

No.	Locality.	Marl-slate.	Yellow Sands.	Remarks.
		Ft. Ins.	Ft. Ins.	
1	Hartley	Denuded	+15 0	Capping the cliff in small outliers, just south of the old Limekiln.
2	Cullercoats	3 0	+70 0	On the coast between the Ninety-fathoms Dyke and the northern end of the "Baths." Thin limestones in the upper part of the sands. Marl-slate highly fish-bearing.
3	Whitley Quarries ..	3 6	(?)	Top of sands only reached.
4	Tynemouth Cliff ...	3 0	22 0	The sands thin to less than 10 feet here to the west.
5	South Shields ..	Denuded	(?)	The sands have been met with in the immediate neighbourhood, but details are wanting.
6	Harton Toll Bar ..	Denuded	(?)	The sands were formerly visible here (Mr. W. Hutton).
7	Simonside, near Westoe	0 11 (?)	None	*Boring* (vol. v., page 155).
8	West Boldon ...	(?)	Thin	In cutting the foundations of a house below the quarry and below the church, and in a well near the Rectory gate (Mr. W. Hutton).
9	Down Hill, near West Boldon	2 6	+10 0	Fish found in the Marl-slate here.
10	Hylton Castle, near	(?)	Thick	"In dell running from the Wear to Hylton Castle" (Mr. W. Hutton).
11	Pallion	7 0	Thick	
12	Claxheugh	Nil to 4 0	Very thick	Mr. W. Hutton describes the yellow sands here as of immense thickness. They are certainly more than 70 feet.
13	Wearmouth Colliery	8 10	5 0	*Sinking* (vol. iv., page 96).
14	Humbledon Hill ...	9 10	+10 4	*Sinking and boring* (vol. iii., page 270). Here there is a thin bed of yellow sand (6 inches thick) immediately above the Marl-slate. The thick sands are described as yellow above and brown below.
15	Pensher Hill ...	(?)	Thick	Sands seen on north side of hill.
16	Silksworth Colliery	2 6	7 0	*Sinking* (vol. v., page 151), No. 1 Shaft.
17	Ryhope Colliery	1 1	96 6	*Sinking* (vol. iv., page 322), North and West Pits. In this section, the sands are divided into ten members chiefly characterized by variety of colouring, dark, white, brown and yellow. Fish occurred in the Marl-slate.
18	Seaham	3 0	8 4	*Boring* (vol. v., page 41). Thickness of sands doubtful.
19	Seaham Colliery ...	(?)	8 6	*Sinking* (vol. v., 42), Union Pit. Marl-slate no doubt present, but not identifiable.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate. Ft. Ins.	Yellow Sands. Ft. Ins.	Remarks.
20	Seaham	4 2	6 0	*Sinking*, 1849 (vol. v., page 45). Thickness of sands doubtful.
21	Eppleton Colliery ..	(?)	36 0	*Sinking*. Downs Pit. The sands were in this case dry.
22	Do do. ...	(?)	110 9	*Sinking* (vol. ii., page 301). Jane Pit.
23	Murton Colliery ...	2 6	34 6	*Sinking* (vol. iv., page 116). East Pit.
24	Do. do. ..	2 0	27 8	*Sinking* (vol. iv., page 117). Middle Pit.
25	Do. do. ...	3 3	26 0	*Sinking* (vol. iv., page 120). West Pit. What has been taken here as Marl-slate is given as 2 feet 3 inches of blue metal and 1 foot of white metal. What the latter may be is doubtful.
26	Hetton	4 6	2 4	*Boring*, 1793 (vol. iii., page 219). This is a very doubtful section; a limestone 1 foot 8 inches thick is said to underlie the "marl with sand in open gullets" which is here taken as the Yellow Sands.
27	Elemore Colliery ...	1 3	62 10	*Sinking* (vol. ii., page 275). George Pit. The upper part of what is probably the Marl-slate is said to be a "yellow clay."
28	Do. do. ...	1 7	63 0	*Sinking* (vol. ii., page 277). Isabella Pit. In this case the lower portion of the probable Marl-slate is said to be clay.
29	South Hetton Colliery	2 0	None	*Sinking* (vol. v., page 162). Engine Pit.
30	Easington	2 4	(?)	*Boring* (vol. ii., page 266). The sand was merely touched by the boring.
31	Haswell	(?)	24 2	*Boring* (vol. iii., page 168) near Shotton.
32	Haswell Colliery .	3 3	60 0	*Sinking* to sand, then *Boring* (vol. iii., page 169). Engine Pit, 1831.
33	Do. do. ..	(?)	None	*Sinking* (vol. iii., page 169). Engine Pit, 1833.
34	Haswell	(?)	143 8	*Boring* (vol. iii., page 172). No. 1 hole. The upper 69 feet of the sand was dry. Beneath the sand are 13 feet 7 inches of "soft freestone or sand with grey metal partings." If this forms part of the sand, then the total thickness would be the enormous one of 157 feet 3 inches.
35	Do.	(?)	None	*Boring* (vol. iii., page 173). No. 2 hole. 4 inches of yellow clay occurs in this section immediately below the Magnesian Limestone or Marl-slate.
36	Do.*	3 9	+108 0	*Boring* (vol. iii., page 173). No. 3 hole. The bottom of the sand was not reached.

* Mr. T. Y. Hall states that, at the Old Haswell Pit, the quicksands (or the Yellow Sands) were [illegible] feet thick; that in one borehole "where the present pit is" there were none whatever, and that in the next one the hole was in 96 feet of sands.—"The Extent and Probable Duration of the Northern Coal-field" *Trans. N.E. Inst.*, 1854, vol. ii., second edition, pages 178 and 179

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate.	Yellow Sands.	Remarks.
		Ft. Ins	Ft. Ins.	
37	Shotton, near ...	12 3 (?)	24 2	*Boring* (vol. v, page 145). The Marl-slate is probably not more than 3 or 4 feet thick at most.
38	Shotton Colliery ...	3 8 or 1 4	24 3	*Sinking* (vol. v., page 146). Engine Pit. The beds here taken as Marl-slate are given in the section as strong blue limestone, in thin pannels, 2 feet 4 inches, and blue and grey metal, 1 foot 4 inches. Possibly the latter only is the Marl-slate.
39	Do. ...	3 4 or 1 4	37 0	*Sinking* (vol. v., page 148). New Pit, 1840. Here again the Marl-slate is in two beds, the lower of which is 1 foot 4 inches.
40	Ludworth Colliery...	3 4	(?)	*Sinking* (vol. iv., page 41). Here the section beneath the Marl-slate is: Grey and brown post, 29 feet 8 inches; metal parting, 4 inches; and red and grey post and water, 18 feet. If the whole represent the sands, they would be 48 feet.
41	Thornley Colliery ...	1 6	36 0	*Sinking* (vol. v., page 273).
42	Castle Eden Colliery	12 0	12 0	*Sinking* (vol. ii., page 18). Maria Pit. Perhaps the bottom 10 inches only (described as grey metal) of what has been here taken as the Marl-slate is to be properly so called.
43	Houghton-le-Spring	5 0	60 0	Many fishes were got from the Marl-slate here. The latter has at its base thin brown clay in layers, alternating with the calcareous slabs.*
44	Kelloe	1 1 (?)	None	*Boring* (vol. iii., page 287) by the side of the lane from Kelloe to Cassop Hill.
45	Kelloe Colliery .	2 10	None	*Sinking* (vol. iii., page 289). North Pit, East Hetton or Kelloe Colliery.
46	Kelloe	(?)	None	*Boring* (vol. iii., page 290). Low part of Kelloe royalty. 21 feet 7 inches of alternating blue limestone and dark metal represents the Marl-slate.
47	Kelloe Colliery ...	3 10	None	*Sinking* (vol. iii., page 291). New Pit. Probably the "dark metal" here taken to mean the Marl-slate is the lowest number of the alternations mentioned in the last note.
48	Coxhoe	2 0	1 11 (?) or None	*Boring* (vol. ii., page 151), 1840. The Yellow Sands may be absent altogether. The 1 foot 11 inches bed given here is described as a "strong grey post, with water," and is possibly Coal-measures.

* Mr. W. Hutton, *op. jam cit.*, page 65, says that from Houghton-le-Spring towards Moorsley and Pittington, and in the quarry at Thickley, an unctuous clay, as well as alternations as above described, is common at the bottom of the Marl-slate.

APPENDIX. - *Continued.*

No.	Locality.	Mar-slate. Ft. Ins.	Yellow Sands. Ft. Ins.	Remarks.
49	Coxhoe Colliery ...	(?)	(?)	*Sinking* (vol. ii., page 152). New Winning, 1843. The information in this section is useless for the present purpose.
50	Cornforth	(?)	None	*Boring* (vol. ii., page 110).
51	Do.	5 2	None	*Boring* (vol. ii., page 113). "Hills and Holes."
52	Cornforth	4 0	None (?)	*Boring* (vol. ii., page 119). 1839. 600 feet west of Garmondsway Public-house. "Brown post with water, 12 feet, may possibly represent the Yellow Sands here.
53	Do.	4 0	None (?)	*Boring* (vol. ii., page 120). 1842. South of Symside Hill. Here again 5 feet 5 inches of "brown sandy post" may represent the Sands.
54	Cornforth Colliery...	3 6 (?)	None	*Sinking* (vol. ii., page 123). George Pit. Here the basement-bed of the Permian is said to be "blue limestone with post girdles," 10 feet.
55	Garmondsway Moor Colliery	5 9 (?)	None	*Sinking* (vol. iii., page 77). West of Anne pit.
56	Garmondsway Moor	2 0 (?)	None	*Boring* (vol. iii., page 77). ½ mile south of pit.
57	Do. do.	1 10	None (?)	*Boring* (vol. iii., page 79). Second hole, 1840. Here a bed of sand 4 inches thick is recorded 18 feet above the Marl-slate. "Brown post with water, 11 feet" beneath the Marl-slate may possibly represent the Sands.
58	Trimdon Grange Colliery	(?)	None	*Sinking* (vol. v., page 322). 1845.
59	Do. do.	0 9 (?)	None (?)	*Sinking* (vol. v., page 323). New Pit, 1872. What has here been taken as the Marl-slate is a thin bed called "strong metal girdle," beneath which come 26 feet of "hard blue limestone, full of spar." Below this again are 22 feet of "soft white post, with partings"; this may be the Yellow Sands? Above the 9 inches (?) of Marl-slate are 4 feet 2 inches of "soft dark gritty sand." A very abnormal section.
60	Trimdon Colliery ...	1 6	20 10	*Sinking* (vol. v., page 318), "sunk in Trimdon staple," 1842. The section of the Sands is here very complete, namely: Light yellow sands, 4 inches; yellow clay-partings, 12 feet; dark yellow sands, 8 feet 6 inches. The middle member is specially interesting.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate.	Yellow Sands.	Remarks.
		Ft. Ins.	Ft. Ins.	
61	Trimdon Colliery ..	(?)	14 9	*Sinking* (vol. v., page 320), 1843. The Marl-slate is no doubt a portion of what is given in this section as 37 feet 6 inches of "dark metal" lying on the Sands, which here consist of 14 feet 6 inches of "brown sandy post with soft partings and water" with 3 inches of "yellow partings" at top.
62	Rodridge or South Wingate Colliery	3 11	31 0	*Sinking and Boring* (vol. iv., page 314). 1841.
63	Thrislington ..	10 0 (?)	None	*Boring* (vol. v., page 282). 1,050 feet north by east of the Hall.
64	Do. ...	4 6	None	*Boring* (vol. v., page 285). Fourth hole, "in the first sinking pit," 1836.
65	Do. ...	?	None (?)	*Boring* (vol. v., page 288). Eleventh hole, 600 feet north of first pit. 1837. A difficult section. The beds about the Permo-Carboniferous junction are given thus: *Permian?*: Gullety limestone, 6 feet 3 inches; sand, 2 feet; red and grey metal, 1 foot; limestone, 6 feet; brown post with water, 2 feet. *Coal-measures?*: Red and blue metal, 1 foot 6 inches; sand, 6 inches; and dark metal, 2 feet 6 inches.
66	Do. ...	?	None (?)	*Boring* (vol. v., page 289). Twelfth hole, Whinney Hill. A "white post" 5 feet thick may represent the Yellow Sands.
67	Do. ...	3 6	None	*Boring* (vol. v., page 290). 639 feet "from the Old Coal Pit."
68	Thrislington Colliery	4 0	None	*Sinking* (vol. v., page 291). Jane Pit, 1867.
69	Ferry Hill	3 2	None (?)	*Boring* (vol. iii., page 30). Fifth hole, 1836, east end of Ferry Hill.
70	Do.	13 4	None (?)	*Boring* (vol. iii., page 32). If there be any yellow sands here, they are but 3 feet thick.
71	Fishburn	6 7	None	*Boring* (vol. iii., page 38). "Near Fishburn."
72	Do.	1 0 (?)	None	*Boring* (vol. iii., page 39). Third hole, "in Miss Chilton's Quarry," 1837.
73	Hardwick	?	None	*Boring* (vol. iii., page 137). No. 1 hole, 1,500 feet from Sprucely Farmhouse.
74	Do.	4 9	None (?)	*Boring* (vol. iii., page 138). No. 2 hole, 450 feet from Bishop Middleham Village, 1839. A thick "brown freestone with water" may possibly represent the Sands.
75	Great Chilton ...	9 4	None	*Boring* (vol. ii., page 38). 1828.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate.	Yellow Sands.	Remarks.
		Ft. Ins.	Ft. Ins.	
76	Little Chilton ...	1 6	6 5 (?)	*Boring* (vol. ii., page 39). 1834.
77	Do. ...	?	19 0 (?)	*Boring* (vol. ii., page 41). 1838.
78	Chilton Colliery ...	?	69 0 (?)	*Sinking* (vol. ii., page 43). No. 1 Shaft, 1872. The sands in all these Chilton sections are doubtful
79	Mainsforth Colliery	15 6 (?)	None	*Sinking* (vol. iv., page 48). B Pit.
80	Bishop Middleham Colliery	9 6	None	*Sinking* (vol. i., page 147). Bishop Middleham Pit, 1846.
81	Ryal	?	?	*Boring* (vol. iv , page 320). 1874. Although this is a diamond-boring, yet the record leaves one quite in the dark as to the details of the junction-beds; "limestone" and "sandstone" is all that is given.
82	Rickwall Grange ...	2 0	None (?)	*Boring* (vol. iv., page 305). 1875. Here again, though the Marl-slate is given, it is not possible to say whether the "grey post" which come below and is underlain by "yellow sandstone," may not possibly represent the Yellow Sands.
83	Middridge	11 0	None	*Boring* (vol. iv., page 85). 1,500 feet south-east of village, 1837.
84	Middridge Colliery	?	None (?)	*Sinking* (vol. iv., page 86). Charles Pit. A "yellow post" immediately beneath the limestone may possibly represent the Yellow Sands.
85	East Thickley	4 6	None	*Boring* (vol. v., page 267). Right hand of lane leading to Middridge, 1834.
86	Nunstainton	13 0	None	*Boring* (vol. iv., page 196). 2½ miles east of Rusheyford.
87	Do. ..	?	None	*Boring* (vol. iv., page 198). 240 feet south from Stoney Hall.
88	Do.	2 0	None	*Boring* (vol. iv., page 199). In field near Standalone.
89	Seaton Carew ..	?	None	Diamond-boring, 1888. The 40 feet of dark grey limestone is the lowest Permian in this section, and of this the bottom portion may be Marl-slate. The 27 feet 6 inches of grey and red sandstone beneath are in all probability Coal-measures and not "Lower New Red Sandstone" as given in the record. (Mr. W. J. Bird, *Trans. Manchester Geol. Soc.*, 1888, vol. xix., page 572.)*

* *Trans. Inst. M.E.*, 1890, vol. i., page 343.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that the Marl-slates, which were described in Prof. Lebour's paper as *kupferschiefer*, produced copper-ore. Prof. Lebour made no reference in his paper to the composition of the Marl-slate, and he (Mr. Atkinson) asked whether any appearance of copper had been observed in the county of Durham. He believed that copper-ore had been observed in the Magnesian Limestone about Gardmondsway, but he did not know whether it occurred in the Marl-slate.

Mr. David Burns said that no copper was found in Cumberland in the corresponding beds, and he thought that there was no trace of copper in the Durham district. He had spent a few weeks among the corresponding strata in the Perm district, where copper was very prevalent.

Mr. J. T. Stobbs (Stoke-upon-Trent) wrote that, as might be expected, Prof. Lebour's paper was an able summary of our present knowledge of the relation of the Permians to the Coal-measures in North-eastern England. Of the junction-beds, the Permian Yellow Sands, when present, offer peculiar difficulties in shaft-sinking, and later in the extraction of the upper coal-seams, chiefly because of their natural incoherence and their water-bearing character. Hence, any contribution to the knowledge of the laws of their distribution would be most welcome to those responsible for the development of the eastern portion of the Durham coal-field. It has been ascertained that this distribution is somewhat erratic, and that the Yellow Sands fill the hollows of an old-land surface (that is the floor), which, generally speaking, slopes to the east. General knowledge, however, on this point is not enough, and detailed information respecting these indentations is the great desideratum at the present time, so that the existence or absence of these beds beneath the Magnesian Limestone may be predicted, at any given locality. He (Mr. Stobbs) could not agree with Prof. Lebour's statement that "every record of a . . boring through the junction between the Permian rocks and the beds beneath them . . . . yields a truthful item or datum towards the construction of a contoured map of this ancient floor."* The Appendix shows no

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 372.

less than 30 borings, which report an absence of the Yellow Sands at this junction, and he (Mr. Stobbs) was of opinion that the greatest caution should be exercised in accepting negative evidence from a bore-hole in ground of this character, especially if put down by a system employing hollow rods, down which water is forced. Parallel cases might be quoted from the Ballarat district of Victoria, where shafts, sunk through basalt overlying the denuded Silurian, were completely lost by the inrush of water-bearing "drift," which was reported by bore-holes (put down within the last 25 years) as non-existent. With respect to the time-measure of the unconformity between the Permians and the Coal-measures, it might be pointed out that the "earth-movements" and "denudation" of sections (2) and (3)* were undoubtedly, to a large extent, contemporaneous. The time required for denudation of a given thickness of rocks depended very largely on their hardness, and their position: at any rate, he (Mr. Stobbs) was not inclined to exaggerate the time necessary for the removal of the Upper Coal-measures in Northumberland and Durham, some patches of which were now known to exist in place in Northumberland.

Mr. Walcot Gibson (London) contrasted the difference in the character of the basal beds of the Permian in the North of England with that in Nottinghamshire on the south, where the basal Permian was a strong breccia-band of great service to the miner. The Eolian origin of the Yellow Sands would form one more link in the evidence connecting the Permian and Triassic rocks into one system. He was glad to see attention drawn to the correct age of the red rocks beneath the Yellow Sands. In Nottinghamshire, the Permian rested quite discordantly on at least two horizons of red sandstone—on one high up in the Coal-measure sequence, and on another much lower down. The question as to the nature of the Permo-Carboniferous boundary was one of great interest, alike to the miner as to the geologist, and had received but scanty attention of late years. Signs of a revival of interest were therefore welcome.

Prof. G. A. Lebour (Durham College of Science) wrote, in reply to Mr. Atkinson, that to his knowledge no copper-ore had been found in the Marl-slate of Durham or Northumberland.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 373.

Abroad, carbonate of copper was very common as an impregnation in that deposit—hence its name *kupferschiefer*. At Garmondsway, as Mr. Atkinson stated, copper-ore occurs in the Magnesian Limestone, but in distinct veins of copper-pyrites, weathered externally into green carbonate of copper, not disseminated through the stone. It is quite possible, though he (Prof. Lebour) thought that it had not yet been proved, that this vein, or other similar veins, if traced below into the Marl-slate, will there prove to be still copper-bearing, but not in the manner in which the bed is copper-bearing in the typical *kupferschiefer* of the Continent. The persistent association of copper with the Permian abroad is a most striking phenomenon, and one which has not yet been fully accounted for. In northernmost England, however, this association is not marked, since the infilling of a fissure-vein need not have any direct connexion with its containing walls at any given point. The subject did not, therefore, come within the scope of his paper.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a hearty vote of thanks to Prof. G. A. Lebour for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

The Rev. W. NALL read the following paper on "The Alston Mines":—

THE ALSTON MINES.

BY THE REV. W. NALL, M.A., ALNHAM VICARAGE.

History of the Mines.—The earliest fragment of authentic information concerning the Alston mines is contained in a document dated A.D. 1131. It is an account of certain moneys, which were due to the King from the burgesses of Carlisle in respect of a certain mine, called the Carlisle silver-mine, which was held by them from the King under a lease.

Subsequent accounts enable us to identify the so-called silver-mine of Carlisle with the lead-mines of Alston. Lead-ore contains silver—in various proportions—in combination with the lead; that obtained from Alston moor contains about 10 ounces of silver to the ton of lead. The Rev. John Hodgson—to whose researches we are mainly indebted for our knowledge of the early history of the Alston mines—states that the Northumberland Pipe Roll of 1226 contains a charge of £2,154 for the old rent of the mine of Carlisle, and that this charge is carried forward annually through the whole of that reign, that is to say, until 1272.* Assuming the reliability of Mr. Hodgson's information, we are safe in concluding that the Alston mines were, during that early period, very rich; for £2,154 of that age represents the large sum of £10,000 of our current coin. And yet this sum represented only the rent of the mines, and it did not include the profits realized by the lessees, nor the expenditure for labour and mining requisites.

The expression "old rent," which occurs in the Northumberland Pipe Roll, suggests the idea that the Alston mines were even at that time considered to be old. It may be inferred from the facts just adduced, and from the further fact that the church at Alston was built and the parish formed in 1154, that there was a considerable population in the district in the twelfth and thirteenth centuries. The rent obtained from the lessees of the mines formed a considerable proportion of the revenue of the

* *History of Northumberland*, 1840, vol. iii., part ii., page 45.

Crown, and is sufficient to account for the interest which the Kings of England took in the lead-mines and for the privileges which they granted to the miners.

Henry III., in 1234, warned his bailiffs and faithful people that he had taken under his protection and defence all his mines of Aldeneston (Alston), their men, lands, goods, rents, and all their possessions, and, therefore, commanded them to maintain, protect and defend them, neither giving them nor suffering them to receive from others, hindrances, injury, loss or trouble; and if they had suffered by forfeiture, forthwith to make them amends. In 1235, a royal mandate signified to all the miners in Cumberland that, on repairing to work at the King's mines at Aldeneston, they should not only go there safely and securely, but enjoy all the liberties and free customs, which the miners there had been accustomed to have in times past; and also directed the Sheriff of Cumberland that he should cause all the miners in his bailiwick to go and dig and mine there in his bailiwick, as they had done in times past; and also, the merchants to repair to the same mine with victuals for the miners.*

The wording of the charter suggests the inference that the King had no other mine in Cumberland than that at Alston. Together with the other liberties which the miners enjoyed, was one which gave serious trouble to the landowners and farmers; as they were allowed to cut down the trees, and use the wood in the mines. One case of dispute is cited by Mr. Hodgson as follows: "In Michaelmas term, 1290, Patric of the Gill and 26 other miners at Aldeneston were empleaded by Henry de Whitby and Joan his wife, for cutting-down their trees at Aldeneston by force and arms, and carrying them away." The defence set up by the miners was that they enjoyed the privilege, granted to them by their lord the King, of cutting down the wood, to whomsoever it might belong, which was nearest to the silver-vein, and to take as much of it as they pleased to roast and smelt the ore, to build and to hedge, to give to the agents in lieu of wages, and to the rich in order that they might distribute it to the poor. They also affirmed that the lords of the woods had no right, after that they (the miners) had begun the work of cutting down, to sell or give any of the wood, excepting for reasonable needs, and that they had enjoyed the liberty from time immemorial.†

* *History of Northumberland*, 1840, vol. iii., part ii., page 46.

† *Ibid.*, pages 47 and 48.

The charter of protection having been burnt by the Scotch, Edward III. renewed it on October 23rd, 1334; and again on October 5th, 1335. The King, in 1350, wishing to ascertain what were the liberties, customs and immunities which the miners at Alston and their predecessors had enjoyed, commissioned Thomas de Seton and John de Mowbray to institute an enquiry; who thereupon empanelled a jury at Penrith for that purpose. The jury reported that the miners dwelt together in their shelis [*cf.* shieling], had the liberty of choosing from among themselves one coroner, and one bailiff, who was called the King's Serjeant. The coroner had cognizance of all pleas concerning felonies, debts, and all other matters concerning themselves, and had the power of determining cases. The bailiff was empowered to enforce the decisions of the coroner. There was, however, a proviso to the effect that the miners ceased to enjoy their privileges when they ceased to dwell together in "shelis."

At some time previous to 1359, the Carlisle lessees had either surrendered or forfeited their lease of the mines, for a German, named Tilman, was then in possession of the mines, and had brought over a colony of his own countrymen and settled them on Alston moor. The change of lessees was probably followed by a change of market. While the burgesses of Carlisle were in possession of the mines the produce was no doubt carried to that ancient city and there sold to the lead-merchants; but the Germans seem to have sent the lead, or lead-ore, by way of Stanhope or Hexham to Newcastle, whence it was shipped to the continent—probably to Hamburg. Alston was thus separated from its own county-town of Carlisle, and brought into connexion with Newcastle.

In 1414, the mines were leased by William de Stapleton; and in 1468, Edward IV. granted to Richard, Earl of Warwick, and John, Earl of Northumberland and others, all his mines of gold and silver. On March 23rd, 1475, the King granted to his brother, the Duke of Gloucester, Henry, Earl of Northumberland and others, the mines of Fletchers, which were situated at Gerrard's Gill in Alston parish.

Towards the end of the sixteenth century, the Alston estates, together with the mines, became the property of the Hyltons, of Hylton Castle, near Sunderland. In 1621, Hylton, the lord of the manor, being desirous of providing his daughter with a

marriage-portion, raised the requisite sum by granting leases for one thousand years of the several tenements upon his Alston estates, reserving to his family the right of working the lead and other mines on payment of damages to the lessees. His successor, finding that the mines were not remunerative, and supposing that they were exhausted, sold the property to the Radcliffes, of Dilston. The story of James Radcliffe, the last Earl of Derwentwater, is well known and does not need to be re-told. One of the consequences of the Pretender's attempt upon the throne of England was the settlement of the Derwentwater estates, with the mines, upon the Greenwich Hospital.

The history of mining in Alston moor during the past 150 years would furnish matter for a small volume, but the writer proposes to mention here only the more important facts.

In 1737, most of the mines in Alston moor were held on lease by a Company which was popularly known as the London Lead Company, or the Quaker Company, but traded under the name of the Governor & Company. This Company is still in possession of lead-mines in Teesdale, but in 1882 the directors sold their interest in the Alston mines to the Nenthead & Tynedale Lead & Zinc Company.

During the long tenure of the lease of the Alston mines by the Governor & Company, the mineral resources of the district were thoroughly explored, every vein being carefully traced and mapped, and every stratum being pierced through and through by shafts, adits and drifts. The output of lead-ore, which in the ten years between 1737 and 1747 was only 15,244 bings,* continued to increase, until it reached its maximum of 217,846 bings, valued at £1,000,000, in the decade from 1817 to 1827.

In the trials which were made by the Governor & Company for the purpose of exploring the veins, other minerals, in addition to lead-ore, were discovered, and were to some extent utilized.

Mineral Veins.—A few of the most productive veins which traverse the district of Alston moor may be mentioned here:—The Rampgill vein has probably been one of the most productive in Great Britain. During the period between 1703 to 1886 the

* 1 Bing weighs 8 cwts.

output of ore from this vein in the Greenwich Hospital Manor was 350,000 bings, and almost as much ore was obtained from the same vein by Mr. Beaumont in the Allen's Head mines.

The story of the Hudgill-burn mine is a striking exemplification of the proverb that fact is stranger than fiction. In 1888, the late Mr. Thomas Wilson-Crawhall-Wilson, of Alston, supplied the writer with the following information respecting that famous mine:—

This mine was originally in the hands of two separate companies. One of these drove the Hudgill-burn level to a considerable distance towards the west, or south-west, but failing to discover ore, the agents abandoned the enterprise. About the same time, a person named Todd, who held a plot of mining ground near Galligill, which he explored by means of shafts, also abandoned his lease. Report says that ore was subsequently found within a yard of one of Todd's shafts.

The mining field was now open to any one who cared to try his fortune, and it was at this juncture (1813) that Mr. John Wilson of Nent Hall formed a new company for the purpose of working both the abandoned plots of ground. This company commenced operations in the Hudgill-burn level. Diverting the level from its former course, they drove it towards the south, and entered Todd's old ground, where they cut the Hudgill old vein in the course of the following year, 1814. In subsequent years, they cut other rich veins, and continued for a long time to raise large quantities of ore and to pay large dividends.

During the first year the total expenditure was about £400, no ore being discovered. In 1815, ore, to the amount of 563½ bings, was raised. In 1816, a dividend of £1,680 was paid; in 1817, the dividend was £7,000; and it continued to increase until in 1822 the maximum of £38,000 was reached. The total amount divided among the partners during the seventeen years that the mine continued to be productive was £320,000, which allows an average dividend of £17,500 per annum. The original capital was £500.

Other wellknown mines include Rodderup Fell, Benty Field, Tynebottom, Cash Well and Cross Fell. The writer reserves for further notice the trials which have been made from time to time in the Great Sulphur vein.

Summary.—Between the years 1737 and 1887 the quantity of lead-ore extracted from the mines on the Greenwich Hospital Manor was upwards of 1,600,000 bings; for the whole of Alston moor the quantity must have exceeded 2,000,000 bings. From 1797 to 1827, and again from 1847 to 1867 the average price per bing was £5. A moderate computation of the value of the lead-ore yielded by the Alston mines, during the period of 150 years, between 1737 and 1887, would not fall far short of £20,000,000.

For 21 years, beginning with 1800, the average output per annum from the mines in Teesdale, Weardale, the Allendales and Alston moor with Cross Fell, was as follows:—

Mining Districts.	Bings.
Teesdale	8,000
Weardale	17,000
Allendales	8,000
Alston Moor, with Cross Fell	19,000

In the year 1788, the output of the Weardale and the Allendales mines was 11,391 bings; and of Alston (the Greenwich Manor only) 10,593 bings. During the last quarter of the eighteenth and the first quarter of the nineteenth century, the Alston mines were probably the richest lead-mines in the world.

The royalty on lead-ore in Alston moor during the long period between 1737 and 1828 was at the rate of 1 in 5; from 1828 to 1835, the royalty was 1 in 6 on the east bank of the Tyne and 1 in 7 on the west bank; from 1835 to 1863, it was 1 in 7 over the whole manor; and since 1863 it has varied from 1 in 7 to 1 in 18.

Men who were distinguished for their attainments in natural science travelled from a distance to see the rich lodes and heaps of ore within and near the mines. Among the visitors were Prof. Mohs, of Freiberg, and Count Breuner, of Vienna. Dr. Buckland, Dean of Westminster, inspected the mines, and studied the geology of the lead-mining districts. In 1815, the Dean of Windsor, in his capacity of Director of the Royal Hospital for Seamen at Greenwich, visited the mines, and after inspecting Nent Force level, he characterized it as "a stupendous work," quoting the expression from the report of a former commissioner.

Alston moor was, in those days, a training school, whence mine-agents and engineers were sent to other mining-fields. The Assay Office in Alston was a school of practical science, in which discoveries were made that have been of immense advantage to the owners of mining property and to the country generally. In this office, Mr. H. Lee Pattinson made his famous discovery of a new method of extracting the silver from lead, a discovery which is supposed to have added £5,000 per annum to the revenue derived from the Weardale mines.

In 1796, an attempt was made to obtain Parliamentary power to make a canal from Newcastle to Haydon Bridge. The follow-

ing extracts, taken from a petition presented to the House of Commons by the Commissioners of the Greenwich Hospital, indicate the opinion which then prevailed with regard to the commercial value of the Alston mines.

The canal, by ending as is proposed at Haydon Bridge, will terminate in the very centre of the said Barony of Langley, a situation peculiarly favourable for a repository of wood, iron, and other articles which will be brought from Newcastle for the use of the very valuable lead-mines belonging to the Hospital in the manor of Alston moor; and for the corn and merchandise which will be brought for the supply of the town and neighbourhood of Alston, whereby that country and all the estates of the Hospital there, will be greatly benefitted and improved. That Langley lead-mills, for the smelting of Alston ore, belonging to the Hospital, and Blagill lead-mills, are so situated as to derive very great benefit in point of carriage, as by means of the proposed canal a ready communication will be formed for the conveyance of the Hospital's and the Blagill Company's lead to Newcastle; and for carrying back wood, iron, bricks, and other heavy articles necessary to and used at those mills in return, by which and the other benefits and advantages above mentioned, and by divers others, the revenues of the said Hospital will, if the said Bill shall pass, and the said canal be made, be considerably increased and the estates of the Hospital there in other respects considerably benefitted and improved.

The following is an estimate of the annual savings in the expense of the carriage of lead and materials, if the proposed canal should be made to Haydon Bridge, compared with what is now paid; which includes the other lead-mills at which the lead-ore of Alston moor is smelted:—

No.	Names of Mills, etc.	Owners of Mills.	Present Expense	Estimated Expense by Canal.			Estimated Saving.		
			£	£	s.	d.	£	s.	d.
1	From Langley Mills to Newcastle (Alston ore)	Commissioners & Governors of Greenwich Hospital	720	407	10	0	312	10	0
2	Blagill Mill to Newcastle (Alston ore)	William Jobling & Co. (an Alston Company)	720	407	10	0	312	10	0
3	Capold Mill to Newcastle (Alston ore)	Governor & Company ...	1,440	815	0	0	625	0	0
4	Nenthead	Governor & Company ...	720	407	10	0	312	10	0
5	Tynehead	Utrick Walton & Co. ...	480	271	13	4	208	6	8

N.B.—The foregoing estimate is made upon an expectation that 12,000 pieces of lead will be produced annually at each of the mills Nos. 1, 2, and 4: 24,000 at the mill No. 3; and 8,000 at the mill No. 5. Upon examination of the books kept in the office of the receivers of the Hospital, it is found that in the last seven years, 85,127 pieces of lead have been sent from Langley mills to Newcastle. From hence [*sic*] it cannot be doubted of how much importance it is for the interest of the Greenwich Hospital that the proposed canal on the north side of the river Tyne should be effected.

Geology and Mineralogy.—It is a fact well known to the geologist, that the north-country dales closely resemble each

other in their physical features, and that they have all been formed by the same agencies in the same series of rocks. The rivers Tees, Tyne and Wear have their sources in the same mountain—Kilhope being only a spur from Cross Fell—and in their upper reaches flow within a few miles of each other. From Wear Head to Tyne Head the distance is not more than 6 miles; and from Tyne Head to Tees Head it is not more than 8 miles. At one point in its course, the Tees approaches so near to the Tyne that a mining-engineer was able some years ago, without much difficulty, to conduct some of the water of the former river into the latter. The Tyne-bottom Limestone—a stratum which has derived its name from the fact that it forms the bed of the South Tyne for several miles—appears in the bed of the Tees near the source of that river, and in the bed of Kilhope burn near Heatherycleugh, and is in both these places underlaid by the Great Whin Sill. The Fell Top Limestone crops out on Blagill Fell and Middle Fell in Tynedale, and on the summits of the Weardale and Teesdale fells.

Between the Whin Sill and the Fell Top Limestone lie the Lead-measures, which derive their name from the fact that they are rich in deposits of lead-ore. Of this series of rocks the central mass of the Pennine chain is mainly composed, and to it the dalesmen are indebted for their beautiful scenery.

Near the middle of the Lead-measures occurs the Great Limestone—the characteristic stratum of the series—which forms so striking a feature in northern landscapes. It crops out in great thickness in Tynedale, Allendale, Weardale, Teesdale, and the dales in North Yorkshire. In Tynedale, it forms a natural terrace of great beauty, which runs along the eastern side of the valley from Lovelady Shield to a point above Kirkhaugh church. A partial section of this limestone has been exposed in the quarry at Coatlith hill.

In Weardale, this stratum forms terraces on the sides of the hills and mountains; but nowhere does it appear to greater advantage, as the maker of rich scenery, than in the bed of the Tees near Barnard Castle. The "living-stone and marble-grey," which occur in *Rokeby*, are poetic expressions for limestone, and

"Those cliffs that rear their haughty head
High o'er the river's darksome bed"

are, to speak in the language of sober prose, "limestone tumblers." But though the dalesmen are indebted to the presence of the Great Limestone for their grandest and fairest scenes, it is to the Whin Sill and the Scaur Limestone of the Lead-measures that they are indebted for those natural rockeries which ornament the banks of the rivers, and form the beautiful waterfalls.

The geology of Alston moor may be studied with advantage in the bed of the South Tyne and in the gills which score the slopes of the mountains. The Whin Sill lies near the surface in the village of Garrigill and crops out at Tynehead, while Cross Fell is capped by the Grindstone Sill.

Shafts have been sunk into the Whin Sill at Garrigill, Rodderup Fell and Tees-side. In the Browngill mine, lead-ore has been found in the Grindstone Sill, that is to say, at the very top of the Lead-measures. At Rodderup Fell and on Tees-side lead-ore has been found in the Whin Sill, or at the bottom of the Lead-measures. A careful examination of the list of mines given in Mr. Westgarth Forster's *Treatise on a Section of the Strata from Newcastle-upon-Tyne to Cross Fell* would, the writer believes, show that every stratum between the Grindstone Sill and the Whin Sill has been pierced by the lead-miner in his search for ore. The composition and texture of each stratum have been ascertained and its position in relation to the other strata has been fixed with a considerable degree of accuracy. These remarks apply to the lead-mining districts of Alston moor, the Allendales, Weardale and Teesdale.

The writer will venture to digress for a moment from the subject of this paper, in order to point out that the miner was the pioneer in the science of geology and that our knowledge of the strata and mineral veins has been mainly derived from him. When the antiquity of the Alston mines is considered, the number of men employed in them either as agents or workmen, and the probability that many of the agents were men of ability, the force of this remark becomes apparent.

The geology of Alston moor was the subject of careful study on the part of Thomas Smeaton—the famous engineer—prior to 1776. In that year, the Nent Force level was commenced under the direction of Smeaton. The level was intended to serve the

two-fold purpose of a drain for the Nenthead mines and of a trial of the mineral veins in the Nent valley.* The designer must, therefore, have had some knowledge of the strata in the Nent valley or he could not have devised his working-plans.

It is interesting to note here that William Smith was only seven years of age when Smeaton's great engineering work was commenced. Therefore, the statement made by Prof. Seeley in *The Story of the Earth* that "The law of succession of the layers of rock upon each other" was not discovered until 1790, and then by William Smith, needs some qualification.

Mineral Veins.—In Alston moor most of the veins run in a direction which may be roughly described as east-and-west. A few bear north-and-south, crossing the east-and-west veins at various angles.

The veins which cross other veins are, of course, of more recent origin than those which are crossed by them; hence the belief which is prevalent that the east-and-west veins were anterior in origin to the north-and-south veins. If we might assume that the vein-fissures were caused by shrinkage in the earth's crust, we should arrive at the conclusion that the fissures in the Pennine district were caused by two distinct movements in the earth—the first in respect of time being from north to south, and the other, and more recent, from east to west.

All the veins traverse the Whin Sill, and are consequently of later origin than that sheet of basalt.

The Great Sulphur Vein, or Backbone.—Any account of the geology of Alston moor which did not take notice of the Backbone or Great Sulphur vein, would be incomplete. The writer has, therefore, made a few notes on that vein. Its course is nearly north-west to south-east, being parallel with the course of a dyke of basalt which crosses the Tyne at some distance to the south-west. The proximity and parallelism of those two powerful dykes are circumstances worthy of notice. In what respects do the contents of the Sulphur vein differ from the contents of the other

* The distance from the mouth of the Nent-force level to the first air-shaft, at Nentsbury, is 3 miles. This section was driven on the dead-line (level), and the carriage of materials was effected by means of boats, the level being filled with water to a depth of 4 feet. The next air shaft is at Welgill: about 1 mile above Nentsbury. This section was driven at a higher random (elevation) than the first, and the carriage was effected by means of a railway. The total cost of the level is said to have been upwards of £90,000.

veins in the Alston district? This question cannot be satisfactorily discussed here, because the information respecting the vein is not yet sufficient to enable a definite opinion to be formed upon the subject. Towards the north-west, the Sulphur vein runs into the Pennine fault; towards the south-east it becomes divided into several weak sections; and finally it disappears in the mountain-barrier which divides Weardale from Upper Teesdale and Upper Tynedale. The vein throws up the south-west side to the extent of 180 feet, thus placing the Tyne-bottom Limestone on the one side on a level with the Scaur Limestone on the other side.

In 1820, the Commissioners for Greenwich Hospital re-opened the old workings in Crossgill by means of a level under the Scaur Limestone, which served the purpose of a drain for the mine. They also pierced the north side of the vein, wherein they discovered a collateral string, which contained some copper-pyrites, associated with malachite.

To the north-west of the high ground which forms the watershed between Crossgill burn and Black burn, a little stream, well known to the miners and shepherds as the Cash burn, takes its rise and flows almost due north until it joins the Black burn. The Sulphur vein appears in the bed of this stream, and the ruins of old mines are distinctly visible. Two shafts have been sunk into the vein, and a quantity of pyrites brought to the surface. Still farther north-west, in the Smittergill burn, a trial was made by Messrs. Paul & Co., and a small deposit of lead-ore was discovered.

Towards the south-east, near the confluence of the Clargill and Darngill burns, a little lead-ore was obtained from the vein, and trials were made in it on the top of Yad Moss, by the late Mr. Jacob Walton, of Green Ends, Nenthead. The results of those trials were not such as to justify a further expenditure of capital.

The above facts seem to show that the contents of the Great Sulphur vein are poor in quality, that the deposits of lead-ore are too few and small to repay the cost of mining operations, and that copper and sulphur are not present in the pyrites in sufficient quantities to repay the cost of extraction. But it should be borne in mind that the processes for extracting metals have been greatly improved since the above trials were made, and that ores which were formerly regarded as worthless rubbish are now being

turned to good account. Our forefathers buried thousands of tons of black-jack (blende) in the dead-heaps, believing that the material was of no use; but the blende is now being disinterred, and from it is extracted a metal which is more valuable than lead.

In 1872, the Tynehead Manor, which is the property of Colonel Byng, was surveyed by Mr. De Rance, who made the following remarks on the contents of the Sulphur vein:—

> No assay of magnetic pyrites (pyrrhotite) from the Sulphur vein has been made. It is possible that it may be associated with the valuable metals, cobalt and nickel, as is the case in some German ores; and whether this be so or not, it is certain that it contains a sufficient quantity of sulphur to make it valuable for the manufacture of crude sulphuric acid. The residues obtained from the pyrites, in the manufacture of sulphuric acid, are employed, when pure, as iron-ore, in Cleveland, under the name of "blue billy."

In the early part of the nineteenth century, a valuable deposit of copper-ore was discovered in the Stow Crag vein, Tynehead, and a smaller deposit was found in the Sir John's vein. Both of these veins are closely associated with the Great Sulphur vein. The bearing of the Sir John's vein is almost due north-and-south. It traverses the left bank of the South Tyne, from Dry burn to Tynehead, crossing the river at a point which is a short distance to the west of the confluence of the Darngill burn with the South Tyne. The Sulphur vein crosses the river, a little farther to the west, and as its course is north-west to south-east, it intersects the Sir John's vein on Yad Moss, and removes it from its course to the extent of 120 feet. Both veins disappear on Tynehead fell.

Copper.—Small quantities of copper have been found in the Sulphur and Sir John's veins at Crossgill and Tynehead. One valuable deposit was discovered in the "hazel," about the middle of the last century in the Stow-crag mine (Tynehead) in the Sir John's vein.

Limestone of excellent quality abounds in Alston moor.

Three seams of coal occur in the Lead-measures, of which the two associated with the Little limestone were formerly utilized for domestic and agricultural purposes. Crow coal has now disappeared from the domestic hearth, though it is still used in the lime-kiln.

This account of the Alston moor mining district is not exhaustive—the names of many veins having been omitted. Among the

veins passed over are Carrs, Cowhill, Cow Slitt, the Great Cross veins in Handsome Mea and Rampgill mines, Black Ashgill, Low Fair Hill, Patterdale and Galligill, Woodhouse, Hanging Shaw, and Scraith Head, in the Nenthead district; and the following in Garrigill: Thortergill, Old Groves, Howhill and Hardsyke. Every one of those veins has been the subject of one or more trials, and some of them have yielded ore; but none of them can be relied upon as a source of mineral wealth.

The cross veins are not productive, excepting at, or near, the places where they intersect the east-and-west veins, and in most of those places they have already been tried.

The minerals found on Alston moor include:—Alstonite; anthracite; barytes, sulphate and carbonate; baryto-calcite; black-jack or blende; calamine; copper; fluor-spar; galena, the principal ore of lead; iron pyrites; limestone; and quartz, the chief mineral in the Sulphur vein.

The PRESIDENT (Sir Lindsay Wood, Bart.) said that the members were very much obliged to Mr. Nall for his interesting paper on the ancient working of the mines in the Alston district. The quantity of ore got in those days was very much larger than was produced at the present time on account of the best mines having been very largely exhausted. These mines were not now being worked, owing to the great fall that had taken place in the price of lead—50 per cent., if not more—and that, of course, made a great difference when they had to work the poorer mines and those below water-level. The mines at Alston were now, he believed, worked for zinc, the lead being a bye-product, instead of *vice versa* as in the olden days.

Mr. ANTHONY WILSON (Thornthwaite, Cumberland) said that he had listened with interest to the history of the Alston mines. Reference had been made to the working of the mines in the early days by the Germans, and history had repeated itself, as the whole of the workings at present being carried out round and about Alston were now practically in the hands of a German company, who worked them on a highly scientific basis. The Institution of Mining Engineers would do great good if it were to consider this subject, and obtain papers on lead- and zinc-mining in Great

Britain. One could not help but think that if downright energy and capital were put into lead- and zinc-mines the result would be satisfactory. They had seen one or two examples of work being carried out on a large scale by foreign companies, and it made him feel ashamed at their own lack of energy. The industry of lead-mining was practically dying out, and he hoped that the knowledge of the ancient history of these mines would result in mining-engineers throwing more energy into this branch of mining.

Mr. LUKE WILLIAMS (Tasmania) said that Mr. Nall had told the members that the ore contained about 10 ounces of silver to the ton of lead, and as one greatly interested in lead- and silver-mines in the Colonies he would like to know the average width of the vein and the percentage of lead in the crude ore.

Mr. HARRY RHODES (Rotherham) asked whether Mr. Nall could give further information as to the occurrence of anthracite. It seemed curious to come across anthracite in the Alston district.

The Rev. W. NALL replied that three seams of coal were found in Alston moor, the two best seams being associated with the Little Limestone. The thickest was only 18 inches, and the other one only 12 inches in thickness. The coal was of a poor quality; it was used for lime-burning, but was not used in the cottages of the miners. It contained large quantities of sulphur.

The PRESIDENT (Sir Lindsay Wood, Bart.) said that as much as 80 per cent. of lead was found in some of the ore, and in others not more than 20 per cent. It varied very much in the veins and in different parts of the same vein.

Mr. LUKE WILLIAMS asked what was the minimum quantity of lead profitable to work.

Mr. W. M. EGGLESTONE (Stanhope) wrote that the historical part of Mr. Nall's paper on the Alston mines was very interesting, and gave one a glimpse of many lucky speculations in mining for lead-ore, and also of the contrivances for working the mines, the discoveries for extracting silver from the galena, with other events and incidents associated with a famous mining district seamed with metalliferous veins. In the geological part of the paper it was stated that—"The Tyne-bottom Limestone . . .

appears in the bed of the Tees near the source of that river and in the bed of Kilhope burn near Heatherycleugh, and is in both these places underlaid by the Great Whin Sill."* A reference to the maps of the Geological Survey, or an examination of the exposed section of strata in the bed of Kilhope burn, near Heatherycleugh, Weardale, would show that the Great Whin Sill here underlies the Single Post Limestone. This limestone in the section is a one-post stratum, 5 feet thick, and not at all like the Tyne-bottom Limestone, with its three flats and a thickness of 24 feet, less or more. Burtree-pasture mine, in the same neighbourhood, is now closed, but the section of the engine-shaft shows the same change of horizon of the Whin Sill—underneath the Single Post—to that assigned to it by Mr. Westgarth Forster, namely, underneath the Tyne-bottom Limestone.† He (Mr. Egglestone) had read a paper on the subject of the change of horizon of the Whin Sill at Stanhope, at a meeting of the Weardale Naturalists' Field Club in 1902.

Mr. J. Cameron Swan (Newcastle-upon-Tyne) wrote that Mr. Nall's interesting paper on "The Alston Mines" invited comment at some points of the story which he had so effectively told.

As regards the antiquity of the mines, there was no doubt that they were being worked at a period earlier, probably much earlier, than the date, 1131, at which authentic documentary evidence of their existence began, and they were mentioned in a manner which proved that the mines were then of great value. and must, therefore, have been in operation for the considerable period which (especially in those primitive times) would be necessary to bring them into the condition of such extensive and profitable working.

It had been stated with some confidence that the mines were worked by the Romans. They were on the spot, and the remains of the large station on the Maiden Way, at Castle-nook, 2 miles from Alston, were well known. But there was no direct authentic evidence that they raised lead in Tynedale. No Roman mining implements appear to have been found in old mine-workings, such as had, from time to time, been discovered in ancient mines in Spain and elsewhere.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 399.

† *A Treatise on a Section of the Strata*, by Mr. Westgarth Forster, 1883, third edition, pages 61, 62 and 99; and Mr. D. Burns, *Trans. N.E. Inst.*, 1877, vol. xxvii., page 85.

He (Mr. Swan) might mention that one of the workmen at Nenthead told him that, when he was a washer-boy at Blagill mine, among the débris which came out of the ancient workings were the "antlers of deer, and fragments of rope made of leather." Blagill was the oldest of the more important mines at which some work had been carried on until present times. The leathern-ropes pointed to a date before the use of hemp for rope-making; and the deer's antlers pointed to the remote period when the hills were, to a great extent, covered with growing timber and were the natural habitat of herds of wild deer. It might be worth mentioning that the name of this very old mine confirmed Mr. Nall's statement that at a certain time the Alston mines were leased and worked by Germans, for "bla" was only a slight corruption of the German "blei" (lead), and Blagill is, in effect, Blei-gill or Lead-gill.

Mr. Nall mentioned that the leasing of the lead-mines to the Germans led to the diversion of the lead-trade from Carlisle to Newcastle. It also led to the naming of a portion of the old parish of Ryton, where there was anciently a lead-smelting works, and doubtless, in consequence of being made the place for the storage and accumulation of the lead from the west country, it acquired the name of Bleidon, or Blaydon, as we know it. Blaydon, it will be remembered, is the first point at which the Tyne becomes navigable for serviceable craft; and to this point came all the lead produced at the mines near the headwaters of the Derwent, Allen and Tyne, and at the extensive mines of Fallowfield, near Hexham. Thence it passed to "keels," and was carried by them down the river for treatment at Newcastle factories, or for shipment oversea.

The mine of "Fletchers at Gerrard's Gill," mentioned by Mr. Nall as having been granted by King Edward IV. in 1475, to his brother, the Duke of Gloucester and to the Earl of Northumberland, was no doubt the mine, in the Tyne valley, that we know as Fletcheress, and Gerrard's Gill, is, of course, our modern Garrigill.

The definite manner in which, in ancient leases and other documents, the mines of Alston are spoken of as "the silver-mines," appears to indicate that the mines we know were richer in silver when worked in the upper strata, or that there were other mines with which we are unacquainted, the ores from which contained a higher percentage of this metal than does the mineral

obtained from existing workings. The lead-ore now produced in the Alston district is not rich in silver. The average of Nenthead and of Weardale lead-ores is only about 7 to 8 ounces per ton of pig-lead. The ore of Greenhurth mine, in Upper Teesdale, and of Cashwell mine, at Crossfell, contains 10 to 13 ounces per ton of lead. The richest lead-ore that he (Mr. Swan) ever obtained from the Nenthead mines showed 16 ounces to the ton of lead, and this was produced from a very narrow string connected with the Rampgill vein. The ore, of which very large quantities have been raised, from the flats on and between the parallel north-and-south veins, known as the Great Cross vein and Smallcleugh Cross vein, contains no silver.

At one time, there must have been in the district, if not immediately at Alston, mineral very much richer in silver. Even so recently as the beginning of last century, some of the mines (Thortergill mine and Nentsbury mine, for instance) were yielding ore containing 21 ounces of silver to the ton of lead. And from time to time, pieces of "float-ore" have been picked up at or near the surface, and in the beds of water-courses, which have given high percentages of silver, some as much as 120 ounces to the ton of lead. One large boulder of ore, which weighed 2 cwts., contained over 90 ounces of silver to the ton. Close search was made for the lode from which this splendid mass of ore might have been derived, but it has never been discovered.

The exhaustion of many mines, and the reduction of the values of both lead and silver, have so unfavourably affected mining in the Alston district, that, but for one fortunate circumstance, it is not improbable that this ancient and useful industry would have nearly reached the point of extinction. At this moment, when the prices of lead and of silver have fallen so low, there has arisen a demand for zinc, which has made the ores of that metal of substantial value. And blende or "black-jack," which was worse than useless, and an actual source of trouble and of loss to the miner, has proved, for the time being at any rate, the salvation of the industry. For the Alston mines, or many of them, are rich in sulphide of zinc, and with the transfer which Mr. Nall chronicles from the London Lead Company to the Nenthead and Tynedale Lead and Zinc Company, a fresh chapter, which is of some interest, was opened in the history of the mines.

The mines were taken over from the London Company with

the object of working the zinc-ores on the property, in order to furnish supplies to the zinc-works at Tindale Fell. These works were originally built by Mr. James Henry Attwood, one of the brothers of a famous and very able family, of whom the best known in the north was Mr. Charles Attwood, the founder of the Weardale Iron-works.

The perception of the fact that there was a future for zinc, and the selection of the site for the works, was evidence of the acumen and remarkable judgment of Mr. Attwood. He had all Britain to choose from, and he certainly managed to make choice of the one spot in which the greatest number of favourable conditions were present. On the death of Mr. Attwood, the works passed into the hands of the company which eventually purchased the Alston mining properties of the London Lead Company.

The Nenthead and Tynedale Lead and Zinc Company immediately commenced the active development and working of the deposits of blende in the Nenthead mines, with results which gave a fresh lease of life to the mining industry. The importance of this change in operations will be noted in the following figures of production. In the last year of the London Lead Company's working, the zinc-ore raised was about 1,500 tons. In the first and subsequent years of the Nenthead and Tynedale Lead and Zinc Company's operations, the quantities raised were as follows:—1883, 2,275 tons; 1884, 2,650 tons; 1885, 3,034 tons; 1886, 3,117 tons; 1887, 3,205 tons; 1888, 3,820 tons: 1889, 4,010 tons; 1890, 3,830 tons; 1891, 3,940 tons; 1892, 5,208 tons; 1893, 5,378 tons; 1894, 5,449 tons; and 1895, 5,550 tons.

At this latter date, the lease of the land on which the zinc-works were built having expired; it was found impossible to obtain a renewal of the lease on practicable terms, and the mines were sold to the Vieille Montagne Company, Liége. The ore is now conveyed to their smelting-works on the Continent, and so the very interesting and serviceable work of the manufacture of metallic zinc came to an end in the North of England. The Belgian company (the largest makers of zinc in the world) being wealthy and enterprising, have continued to develop and to extend largely the workings for zinc-ore, so that the produce of blende from the Nenthead mines for the year 1902 was about 8,000 tons. The Company have leased the mines in the adjoining valley of West

Allen, and are raising there also large quantities of zinc-ore. These mines were standing, and owe their resuscitation entirely to the blende that they contain, the lodes being for the most part the same as those on the Nenthead side of the hill. The number of persons at present employed in and about the mines by the Vieille Montagne Company is upwards of 300, and the money disbursed, about £40,000 per annum.

The utilization of the ores of zinc has, therefore, made a complete and most welcome change in the present condition of mining in the Alston district. But the question which seems by far the most interesting and the most important, both from a scientific and economic point of view, concerns the future of these mines. Mr. Nall says that "every stratum between the Grindstone Sill and the Whin Sill has been pierced by the lead-miner in his search for ore." This is no doubt, speaking generally, correct, and the problem to be solved, and on the solution of which depends the future of metalliferous mining in Alston moor, is, whether the strata below the Whin Sill, say, down to and including the Melmerby Scar Limestone, will prove to be ore-bearing or not? Looking at the section with its strong beds of limestone and hazle and comparatively small intermixture of plate, it does not seem unreasonable to expect that veins in these lower strata should be productive. It must be owned that the general opinion of mining-engineers is not, on the whole, favourable as to the results of the deeper mining. But those directing the operations in the Alston mines for the Vieille Montagne Company, hold strongly to an opposite opinion, and affirm their conviction that mines will be opened in the lower strata as rich as any that have ever been worked nearer the surface. This is the all-important, the truly vital, question for the future of this wonderful old mining field.

Up to the present, there does not appear to be sufficient authentic information on which to base an opinion which might be expressed with confidence. In but very few places in the district has work been done below the Whin Sill. A few mines have been worked with some success in the Whin Sill itself. At Rodderup, west of Alston, where the Whin Sill is 180 feet thick, there is a good mine in it. But below the Whin Sill, where some not extensive work was done, the vein proved poor. At Burtree-pasture and on the Slitt vein to the east of Alston, some trials were made under the Whin Sill, with fair results at the Slitt mine and

rather poor at Burtree-pasture mine. At Greenhurth mine, in Upper Teesdale south of Alston, the Whin Sill was proved 240 feet thick, the vein carried ore all the way down; but nothing was done below the Whin Sill, as, when the bottom was reached, the water was found in such quantity as to drown the mine. At Settlingstones mine, north of Alston, and on the north of the Tyne river, the Whin Sill is 168 feet thick. The lode of carbonate of baryta carried ore through the Whin Sill. The workings are now 120 feet below the Whin Sill on the down cheek, and the lode is here as pure and productive as it has ever been in the upper strata.

The Vieille Montagne Company are engaged in proving the lower beds by an important sinking which they are making on Rampgill vein. They are already about 300 feet below what has hitherto been known as Rampgill low-level. At their last proof, by cross-cutting from the shaft at the Three-yards Limestone, the vein carried good lead-ore. A certain importance is attached to this trial, as it is immediately below the very heavy plate known as the Eleven-fathoms Plate. There was no ore whatever in the lode in the plate; in the Natrassgill Hazle, above the plate, zinc-ore was present, and in the limestone, below the plate, galena was found alone. It is intended to sink down to and prove all the strata to the Melmerby Scar Limestone.

The Rev. W. Nall said that the lead-industry of Alston—if he might apply the term "industry" to the process of picking out pieces of lead-ore from the bed of the Tyne and its tributary streams—was probably as old as the Roman occupation of that district. Lead-mining appeared to have been in a prosperous condition under the Plantagenet and Tudor kings of England, but it declined under the Stuarts. It revived in the reign of George I., and was very prosperous throughout the reigns of the four succeeding kings and the first decade of the reign of Queen Victoria. Speculation upon the future of lead-mining in Alston moor or in any of their northern dales would be an unprofitable exercise. The mineral-resources of the world were being rapidly developed; lead-ore was now being obtained from foreign countries in large quantities and at low rates. The carriage of lead from over-sea to Newcastle cost little more than the carriage from Alston, Teesdale or Weardale. But, while it was well to recognize these

facts, we should not despair of making further discoveries in the unexplored portions of our mineral-veins, and we might reckon among the possibilities of the future the utilization of the contents of the Great Sulphur vein. Let us hope that in the meantime the demand for blende, limestone, and crow coal might not only be maintained, but increased. Why should we not indulge the hope that, as in the past, a long period of depression was followed by a period of great prosperity, so in the future—near or remote—the present depression would be succeeded by a revival in the staple industry of the northern dales.

The PRESIDENT (Sir Lindsay Wood, Bart.) said there was no doubt that the fall in the price of lead was one of the greatest drawbacks to the working of lead-mines in this country. Spanish and other mines were worked entirely for silver, lead being a bye-product, and being sent over to this country practically as ballast. He had pleasure in moving a vote of thanks to Mr. Nall for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

A paper was read by Mr. H. HUMPHRIS on the "Driving of an Inclined Tunnel 496 yards long and a Tunnel 842 yards long, and a Description of a New Method of Slate-quarrying in North Wales."

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Humphris for his paper.

The resolution was cordially approved.

Mr. LOUIS P. BOWLER'S "Notes on the Gold Coast of West Africa" were read as follows:—

NOTES ON THE GOLD COAST OF WEST AFRICA.

BY LOUIS P. BOWLER.

The writer's investigations have extended over an area, 60 miles inland and 100 miles along the coast, taking the town of Axim as a centre, and as far north as Bonsa river and Tumento, thence in a line to Essuasu on the Tarkwa-Sekondi railway, thence to Mansu and the Disc Cove district as the eastern portion, and Appollonia, Tano river and the Ivory Coast as the western portion.

The country is dotted with shallow shafts and native pits, and of the latter there are thousands, some old and some modern. The old workings are shown in the indents, or basin-shaped hollows, carrying trees of large girth and great age. The modern shafts are indicated by the absence of overgrowth and weather-wornness; and, of the latter, it must not be thought that all these workings are for gold, or indicate the existence of gold-reefs. The wily native requires no teaching how to salt a mine, or how to make a glowing statement by emphasizing the fact that his property possesses old native workings. Cunning to the utmost, he knows that by dotting his property with small holes, they pass as native workings, and add to the value of his estate.

But apart from these latter-day holes there are, without doubt, indelible signs of the vast industry of the ancient gold-workers, whose diligence was boundless, and whose knowledge of the value of the numerous outcrops was unrivalled.

The general formation of the country lends itself to primitive methods of mining, and to the easy extraction of the gold from oxidized bands of quartz lying in a clay-slate formation, and from alluvial deposits in the valleys and rivers.

The surface of the country is entirely covered with alluvial or drift-deposits, principally derived from the fractured and weatherworn quartz-veins and lodes that intersect the strata.

An examination of the outcrops of the lodes show that a large proportion have been tilted at various angles from what was

probably their original horizontal position. These beds are composed of semi-solid layers of quartz, resting on clay-slates and sandstones.

The quartz shows a mass of fractured pieces, cemented together and encased in silica. This "quartz-conglomerate" is common throughout the district visited by the writer. In some places it is of a bluish tinge with red oxidized stains, mixed with white silica; in other places, it consists of dark brown, oxidized matter, and dull whitish quartz stained yellow, and in others it is a black stained quartz. These auriferous beds occur in chloritic schists and diorites in some districts.

Many of these layers of detrital matter lie in geological sequence; and it would appear that they were formed during successive periods of dynamical disturbance, during which sedimentary deposits were spread over basins or planes then lying in horizontal positions. Later, these beds were disturbed by upheavals and tilted at high angles, together with the enclosing slates and sandstones. This action, being long-continued, has produced an enormous number of thin beds of alluvium and quartz.

The ancient workings are invariably sunk on the soft oxidized outcrop of the reef; and, where gold was found, the miles of old workings, in a line on one side of the outcrops, showed that the leader had been assiduously followed. There is no doubt that, with their primitive tools, the ancient miners pursued a ready method for the extraction of the gold, which they found in the soft oxidized portions of the reef.

In relation to these surface-beds, it would be interesting to solve the question as to what becomes of them in depth. The writer is of opinion that eventually they will be found to form part of a compact quartz-formation.

Mr. Edward Halse (London) wrote that Mr. Bowler spoke of the lodes or beds being composed of semi-solid layers of quartz, he would like to ask for an explanation of the term "semi-solid" as used here. In the following paragraph, the quartz-conglomerate is said to be a mass of fractured pieces of quartz "cemented together and encased in silica,"* and this also seems to

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 414.

demand an explanatory foot-note. He (Mr. Bowler) also stated that upheaval "long continued, has produced an enormous number of thin beds of alluvium and quartz."* Here there seems to be a confounding of cause and effect, as the alluvial deposits have undoubtedly been upheaved to a certain extent, but they clearly existed before that action and could not have been produced by it. The opinion expressed by Mr. Bowler in the last paragraph was simply pure conjecture, it was not based on any known facts, and did not help us at all in our knowledge of the West African auriferous seams.

Mr. T. B. F. Sam (Cape Coast Castle) wrote that a few remarks enumerating the methods of mine-salting adopted here, might be of great use to the members:—(*a*) Gold (dust and alluvial) is obtainable in the country, and it is nothing new to receive a sample full of nuggetty gold, which is easily detected by carefully separating the dust of the sample from the rock. (*b*) Pottery or firm clay is used to form an admixture with the gold with which the cavities in the quartz are filled, where the dust is absent; and it is detected by crushing the quartz a second time. (*c*) Melted gold had been detected in a sample by the use of a lens. (*d*) Small pieces of gold had been cleverly inserted in crevices of quartz. (*e*) Guns had been charged with gold and fired against the face of a reef, producing specimens, which a true expert could easily detect as fraudulent. These faults have been brought about by the boom producing many eager gold-brokers, who without expert knowledge take every piece of quartz from anywhere as gold-bearing, being even so mischievous as to produce samples of decomposed granite to the equally inexperienced purchaser, and no samples thus obtained should command definite plans.

Evidences of alluvial gold-mining in the country, being of ancient origin, is more apparent the further inland one goes; and by the prehistoric gads or drills picked up from the seaboard to nearly 170 miles inland.

The absence of gold in the quartz of the banket formation shows how much the granite (the bed-rock of the country) had been penetrated with strings of barren quartz, showing that there are only a few main gold-bearing quartz reefs, which easily yield their gold-contents, impregnating the pebble-bed together with

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 414.

the oxide of iron and sand binding them; clay slate being the recent sediment, the colour of which, dark ash, evidences that the graphite from the west and its gold-contents have played a great part.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Bowler, and stated that the members were greatly indebted to colonial members for many valuable papers.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

DISCUSSION ON MR. A. R. SAWYER'S PAPER ON "THE TARKWA GOLD-FIELD, WEST AFRICA."*

Mr. EDWARD HALSE (London) wrote that Mr. A. R. Sawyer, in his valuable paper, stated that "it is difficult to state definitely whether there are several reefs in this gold-field or not,"† but he described two as occurring at Teberibi. He (Mr. Halse), about 12 years ago, endeavoured to show that two reefs, or rather seams, occur at Tarkwa,‡ while at Abosso four seams had at that time been identified, and in the section of the Wassau mine, given in Prof. Henry Louis' edition of Mr. John Arthur Phillips' *Treatise on Ore-deposits,* four reefs are shown, or three conglomerate-beds and one of quartzose sandstone.|| Two of the former, however, are close together, and probably form a portion of one and the same reef. He (Mr. Halse) believed that there is a series of conglomerate-beds in the Tarkwa district, but how many of these will eventually prove to be auriferous, is, of course, another question. Mr. Sawyer described the ore present in the matrix of the conglomerate as hæmatite. The latter word was evidently used in a general sense, for, in reality various oxides of iron are present, not only in the "cement," but also in layers in the sandstone—among others ilmenite or titaniferous iron, and magnetite may be mentioned—indeed the term "black sand" would perhaps not inaptly describe the occurrence. There is little doubt but that the gold found in the striped sandstone and conglomerates is of alluvial origin, and this may account for iron-pyrites not having been found in depth. To whatever age the West African conglomerates may be assign-

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 402; and 1902, vol. xxiii., page 527.

† *Ibid.*, vol. xxii., page 414. ‡ *Ibid.*, 1890, vol. ii., page 71. || Page 730.

able—and they are not unlikely to prove to be much more recent than Mr. Sawyer supposed—a careful study of them will doubtless throw considerable light on the genesis of the gold in those of South Africa.

DISCUSSION OF MR. F. W. PAYNE'S PAPER ON "GOLD-DREDGING IN OTAGO, NEW ZEALAND."*

Mr. F. W. PAYNE (Dunedin, New Zealand) wrote that since writing his paper he had had further opportunities of testing the centrifugal elevators† in different classes of wash, and found that they work almost equally well with fine as with coarse gravel, stone of ¼ cubic inch and less being thrown on to the tailings-stack. The wind exercises some slight influence on such small particles, but as this is as likely, in an average locality, to be in favour of, as often as against, the throwing of the stuff, it is not of serious moment. He found, as would naturally be expected, that it was a great advantage to supply the tailings to the machine as free from water as possible, as the water not only was a serious additional load on the machine but, when converted into a spray by the beaters, created a dense medium for the stones to pass through, and in the case of fine stuff the retardation was apparent As, however, it was recognized to be a source of loss of gold where the water was thus allowed to pass through the screen, and was also easily remedied, this did not offer any obstacle to the adoption of the elevator.

He was aware of the method of operating a dredge by a pilot-house on American dredges, and it might possibly have advantages in the localities where it was used. In New Zealand, the success or failure of many claims depends upon cleaning the actual bottom, and to do this effectually constant inspection of the buckets is required as they come up, and with New Zealand arrangements, the winch-man stands on the deck-level and regulates the depth of dredging from there. From the time when he alters the angle of the ladder to the time when he can observe the effect of his alteration the buckets have to travel from the bottom to the deck-line, but if he was in the pilot-house above the top-tumbler, the whole length of buckets from the bottom-tumbler to the top would have to pass before he could see what effect his every movement on the

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 32.

† *Ibid.*, vol. xxiii., page 538.

winch had made. Two men were employed on Otago dredges: one to look after the fire, and the engine and machinery, and the other to mind the winch exclusively; and he could tell exactly how the dredge was situated by marks on his ropes, through the night as well as in the day, and could stop the buckets by a clutch operated from the winch at any time. He could not see that the placing him in an elevated pilot-house would be of any assistance to him, and in some respects, as already noted, it would put him at a serious disadvantage.

DISCUSSION OF MR. FRED C. KEIGHLEY'S PAPER ON "COKE-MAKING AT THE OLIVER COKE-WORKS."*

Mr. Fred C. Keighley (Uniontown, Pennsylvania) wrote that in making the statement that the Oliver coke-works were the second largest in the world (excepting the plant of Messrs. Jones & Laughlin at Pittsburg at that time under construction) he certainly had in view beehive oven-plants only. Since the paper was written, 100 additional coke-ovens have been added to the Oliver coke-plants, making a total number of 808 coke-ovens.

He agreed with Mr. Greener in the matter of oven-spacing; he believed that 6 inches between oven and oven was little enough to allow for expansion; and he thought that part of the excessive repair-cost was due to the fact that the space between the ovens was insufficient. With Mr. Greener, he also agreed in the belief that the larger the oven the more costly the repairs, but he thought that this was in a measure offset by increased capacity.

It would appear that Mr. Greener had misunderstood that part of the paper which referred to the materials used in construction. He stated that "it was a mistake to use cement or lime in the erection of coke-ovens, as the latter acted as a flux and destroyed the bricks," etc.† If Mr. Greener would refer to the paper, he would find that he (Mr. Keighley) stated that "the brickwork was all laid in loam-mortar, without admixture of lime or cement."‡ Their experience in the Connellsville coke-region was that loam is better than fire-clay for laying the brickwork of the ovens; and it is important to see that the loam does not carry iron. It is possible that the loam of this district is a superior article. They

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 493; 1902, vol. xxiii., page 485; and 1902, vol. xxiv., page 158.

† *Ibid.*, vol. xxiii., page 486. ‡ *Ibid.*, vol. xxii., page 495.

had had little or no trouble with stone-work, where lime or cement was used, excepting that the cement was apt to crumble out in damp portions that were exposed to the action of very cold weather—this, however, had not affected the walls very seriously. He would not think of using either lime or cement-mortar in connection with the brickwork of the oven itself.

As Mr. Greener anticipated, they did not draw the ovens solidly but alternately, having in view the advantages to be derived from the proximity of a hot oven. He (Mr. Keighley) realized that there is a great waste of gases under the present practice, but the Connellsville coke-region is not yet in a position to take up the bye-product question. The larries are so arranged that the coal runs from either side, as may be desired.

He had experienced no great difficulty in burning either 24, 48, 72 or 96 hours coke; but, the very best results were obtained from the 48 hours burning. He had made thousands of tons of 24 hours coke in one month; and found no difference in the quality of the coke, excepting that it was much shorter in length than the longer burnings produced; but it would be well to say in that connection that the success in making 24 hours coke depends largely upon quick work.

He (Mr. Keighley) took no stock in the theory (which Mr. Greener quoted and also deprecated) that in order to obtain coke in the best possible mechanical condition, it should be allowed, as coke-burners describe it, " to soak in the oven " for 6 or 7 hours after it was burnt off.* He found, by actual experiment, that the standing over of a charge after it had been burnt off resulted in loss or wasting of the coke—a period of 10 hours showing a loss of 5 per cent. in weight. In the matter of breeze, which in their practice amounted to about 3 per cent., he might state that this was due largely to the large spaced coke-fork used in the Connellsville region, the space between the tines being 1½ inches. Forks had been tried with ¾ inch tines, but the coke-consumer objected to the increased quantity of small coke resulting therefrom.

As everything in the way of drawing and loading was done by hand, no great reduction in the cost of production could be expected, even in new plants. The cost of labour in the Connellsville coke-region was continually on the increase, and no reduction in labour-costs could be obtained without the introduction of

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 488.

machinery in the drawing and loading operations, and this, so far as relates to the Connellsville coke-region, was still in an experimental stage.

The great thickness of the seam admitted of comparatively cheap mining; yet this cost was also on the increase, as that work was also hand-work, and so far machines had not been successful in the Connellsville seam.

Mr. T. E. Forster read the following paper on the "Undersea Coal of the Northumberland Coast":—

UNDERSEA COAL OF THE NORTHUMBERLAND COAST.

BY T. E. FORSTER.

Introduction.—The Northumberland coal-field extends along the southern portion of the Northumberland coast, from the Coquet to the Tyne, a distance of about 24 miles (Fig. 1, Plate X.).

Roughly speaking, the direction of the general dip of the measures is a little to the south of east, the line of outcrop commencing on the north at the mouth of the river Coquet, and running thence south-west by south.

This direction of the dip may be said to continue over the whole of the field, until a line is reached, eastward of which the beds commence to rise in a south-easterly direction. The course of this syncline is north by east, and nearly at right angles to the direction of the general line of dip. The northern end of the syncline passes under the sea near the river Wansbeck, and the southern end runs beyond the river Tyne, into the county of Durham, between Wallsend and Walker.

The average rate of dip is very moderate, and the field is not troubled by heavy faulting. With the exception of two large faults near the mouth of the river Coquet, the Wansbeck fault, and the ninety-fathoms dyke at the southern end of the field, near the river Tyne, all with an east-and-west course, there are no faults of unusual magnitude.

Coal-seams.—The upper series of seams, which have been chiefly worked in the eastern portion of the field, along the seaboard, are, the High Main, Grey or Main Coal, Yard Seam and Low Main. The lower seams, consisting of the Beaumont, Busty and Brockwell, have only been opened up to a limited extent, but will doubtless come into working on a much more extended scale as they are required. The vertical distance from the High Main to the Brockwell seam is about 750 feet.

The extreme northern part of the field, in the vicinity of the river Coquet, appears to be occupied chiefly by the lower seams, but it has never yet been possible to correlate them exactly with the seams of the district to the south. Between the two portions of the field, there is a belt of ground, the exploration of which has not so far yielded satisfactory results. Such proofs as have been made, point to alterations in the character, not only of the coal-seams, but also of the beds associated with them, and the fact that the lower seams near the Coquet bear no resemblance to those occupying the ground to the south, forms a barrier to their complete identification, which will probably never be entirely removed.

The principal seams of the Coquet district are:—The Radcliffe, Albert, Queen, Princess, Duke and Yard seams, which are found in a vertical distance of about 400 feet. The Radcliffe seam is supposed by some to be the Low Main, and the Princess, the Beaumont of the Blyth and Tyne district, but, apparently, this is a mere speculation.

The following is a brief description of the conditions under which the various seams exist along the coast-line. Commencing at the mouth of the river Tyne, and passing northward, to Seaton Sluice, the measures, owing to the synclinal axis above mentioned, have a south-easterly or seaward rise; and, consequently, the upper seams crop out practically along the coast-line. The lower seams have never been worked in this vicinity, but probably extend seaward for some distance under a workable thickness of cover. The trend of the coast, passing northward, is to the west of north; and, consequently, the synclinal axis approaches the shore-line and the seams along it assume a heavier cover. The section (Fig. 2, Plate X.), from Hartley, past Seaton Sluice and Blyth, through Newbiggin and northward to the mouth of the river Lyne, is intended to shew approximately the position of the beds along this section of the coast.

Along the southern part of the line, the cover is gradually increasing, as the line of the section approaches nearer to the synclinal axis, the Low Main, off the mouth of the river Blyth, lying at a depth of about 400 feet below sea-level, 600 feet at Cambois, with a further dip of about 150 feet to Newbiggin bay, where the large downthrow-fault to the north, known as the Wansbeck fault, is found. North of this the beds rise very rapidly, until

they pass beyond the region of the fold caused by the fault, and regain their normal level and rate of dip. Beyond the Wansbeck fault, they are, however, unexplored along the coast-line, and that portion of the section is compiled from such information as can be got from data obtained slightly further inland. The belt of doubtful ground described above, commences north of the river Lyne, passes Cresswell and stretches into Druridge bay.

Half-way up Druridge bay, at the mouth of the Chibburn, the Coquet district of the coal-field may be said to commence with the southern limit of the workings of Broomhill colliery, abutting on an east-and-west fault. Beyond this, the seams lie regularly for a considerable distance along the shore-line, with a gentle inclination to the east, until they come within the line of influence of the first of the two great faults previously mentioned, towards which they dip heavily. This fault is computed to throw up the beds, 480 feet, to the north; and the second fault (met with about $\frac{3}{4}$ mile farther on) has a throw of about 600 feet in the same direction. Beyond this, the beds rise to their natural outcrop north of the mouth of the river Coquet.

Coast-line.—So far as surface-features go, the coast-line consists of a series of rocky points, alternating with long bays, the shores of which are occupied by hills of blown sand, capping the Boulder-clay, which, generally speaking, covers the whole of the low-lying flat-country in the immediate neighbourhood of the coast.

The promontories usually mark the lines of east-and-west faults, against which the clay generally attains its greatest thickness, thinning gradually in the direction of the rise of the underlying measures (Fig. 2, Plate X.).

At Cambois pit, the clay is upwards of 80 feet thick, gradually decreasing southward to North Blyth rocks, and re-appearing on the southern side of the river, where it lies, about 60 feet in depth, against the cheek of the fault, which forms the northern side of the entrance-channel to Blyth Harbour and thinning again along Blyth Bay to Seaton Sluice.

The bed of the sea may be described as shelving gradually eastward. The different submarine contour-lines have a regular and uniform course: the variations in their distance from the shore, being due almost entirely to irregularities in the coast-line.

The average distance of the 50 feet line of soundings from high-water mark may be taken at about 1 mile, and that of the 100 and 150 feet lines at about 2 and 4 miles respectively. Except in the vicinity of the promontories, the sea-bottom is apparently entirely covered with sand, and the distance to which the clay found along the shore-line extends seaward is altogether unknown and is likely to remain so.

The fact that the distance to which the clay-capping extends seaward is unknown, together with its liability to be thrown out by faults, unfortunately renders it imprudent to take it into consideration as an important factor of safety in fixing the limit of cover for comparatively shallow workings.

The strata, comprising the Coal-measures, consist of ordinary beds of sandstone and shale, with thin beds of fire-clay, generally forming the thill or floor of the coal-seams. The sandstones, or "posts," are usually somewhat open in nature, and generally pass water freely; the shales, or "metals," are closer and more water-tight; while the clays are still more impervious to water. The district is by no means heavily watered; and, as a rule, a great part of the expense consequent on drainage is due to the difficulty of concentrating the underground feeders through the undulating nature of the beds, rather than to the actual quantity of water to be raised to the surface.

The average composition of the strata overlying the Low Main seam at the North Seaton, Cambois and Cowpen collieries is as follows:—

	North Seaton. Per Cent.	Cambois. Per Cent.	Cowpen. Per Cent.
Sandstones	42·17	56·64	45·34
Shales, and shales with thin beds of sandstone	47·97	27·31	40·86
Coal-seams	4·78	4·25	3·73
Fire-clays	5·08	11·80	10·07

Undersea-workings.—The principal undersea-workings in the district are those which have been carried on for many years by the Cowpen Coal Company, Limited, a description of which may be of interest.

North Seaton Colliery.—The earliest undersea-workings were commenced from North Seaton colliery in 1872, in the Low Main seam. This seam lies at a depth of about 670 feet below sea-level

at high-water mark, and is 5 feet in thickness, with a fairly good roof. A barrier, 300 feet in width, was left near low-water mark, and in accordance with the requirements of the Crown agent, acting under the provisions contained in the Crown lease, pillars were left for the support of the overlying strata, amounting to about 40 per cent. of the seam.

In the first instance, an attempt was made to take out the whole of the 60 per cent. to be worked in one operation: pillars being formed 13½ feet wide, and 90 feet long, the bords being driven 18 feet wide and the walls 7 feet wide. It was found, however, that, after a certain amount of ground had been worked in this way, a creep came on, and the face was difficult to keep open.

Recourse was then had to larger pillars: the dimensions being fixed at 45 feet wide by 90 feet long, with 18 feet bords and 7 feet walls. After these had been carried forward some distance, the pillars were split by means of an 18 feet bordways split, the splitting being commenced at the inbye-end of each district and brought back in the same way exactly as in broken working. The result of this altered mode of working was that the creep was avoided, and the 60 per cent. of coal was successfully extracted.

The workings in this seam were carried seaward for a distance of about 1¼ miles from high-water mark, the seam seaward having a slight rise to the south-east, and a heavier dip to the north-west at the northern extremity of the workings. The workings have not been extended seaward since 1887, although a large quantity of coal has been extracted nearer to low-water mark; and, in this case, the seam has been worked on the ordinary bord-and-pillar system, and the pillars removed in the usual way.

A commencement has recently been made to work the overlying Yard seam under the sea, under a cover of 490 feet at high-water mark. The seam is about 2 feet 8 inches thick, with a good roof, and is worked entirely on the longwall system. The gateways are made 33 feet apart, and the spaces between them are carefully packed with stone. The face of these workings is now about ¼ mile from high-water mark, and the workings are lying entirely over the old workings of the Low Main seam, 180 feet below. No barrier is left in this seam between the land-coal and sea-coal.

The limit of cover, up to which the whole of the coal may be

extracted, is fixed at 270 feet, and provision is made in the lease for the exploration of the ground in advance of the longwall workings (after the area already explored in the Low Main seam has been worked over) by means of a drift to be carried seaward, 150 feet in advance of the face, in order to ascertain the position of any intersecting faults. It is further provided that 30 feet of coal, at least, shall be left against all faults having a throw of more than 30 feet, or of which the cheeks are more than 2 feet apart, although roads may be carried through such barriers where required in the ordinary course of working.

Cambois Colliery.—The working of the undersea coal at Cambois colliery was commenced in 1882, in the Low Main seam (about 4½ feet thick) and at a depth, at high-water mark, of about 576 feet. As at North Seaton colliery, it was at first required that 40 per cent. of the coal should be left, in the shape of small pillars. Considering the difficulty of working the small pillars, the great loss of coal caused by leaving them, and the depth beneath the sea-bed, it appeared to the lessees, that, provided proper precautions were taken, no danger could result from the total extraction of the coal up to a certain limit of cover. It was argued that, although large goaves had been formed for many years in the Low Main seam under the land-area worked by the company, and the Yard seam had subsequently been worked above these goaves, without any appearance of disturbance due to the working of the Low Main seam, and without the downward disappearance of any of the water of the Yard seam, it might reasonably be assumed that the intervening strata, 180 feet in thickness, would be sufficient to guard against feeders from above the level of the Yard seam being brought down to the Low Main seam, and that a further allowance would place any fear of disaster from the removal of the pillars of the Low Main seam beyond any reasonable doubt.

Application was then made to the Crown authorities, and permission was accorded to work out the whole of the coal lying under a cover of 360 feet, under certain conditions, the chief of which were as follows:—

1. In the case of longwall workings, the driving of exploring drifts 300 feet in advance of the actual workings, on the lines of the intended main roads.

2. In the case of bord-and-pillar workings, the provision of barriers, 150 feet thick, along the side of the main roads, and of 60 feet barriers along the "side," or branch, roads, with the idea of forming the workings into panels and isolating these panels, so as to enable any one of them to be dammed off in case of heavy feeders being met with.

3. The provision of barriers of coal, 60 feet wide along the sides of any faults met with, having a throw of 18 feet or upwards, or having cheeks, 2 feet apart or upwards.

These workings have since been carried on most successfully, and very large goaves have been formed under the bord-and-pillar system, without any packing or support being put in, and without any more water being met with than is usually the case under the land under similar conditions.

The winnings have been driven seaward for a distance of about 1½ miles from high-water mark, and have been stopped for some years owing to a splitting of the seam which, it is hoped, may prove local, and may eventually be passed through. The main winnings, to the east of the shaft, have risen slightly; and, presumably, are just on the eastern side of the synclinal axis which appears to run towards Newbiggin point.

Cowpen Colliery.—The working of the undersea coal, at Cowpen colliery, was commenced in the Low Main seam (about 4 feet thick), from the Mill pit in 1888. The ground worked to this pit is on the eastern side of the syncline, and the seams rise regularly to the south-east at a gradient of about 1 in 75. The winnings were driven seaward for a distance of about ¾ mile from high-water mark, when a disturbance, probably forming part of the one met with at Cambois colliery, was encountered. It is, however, hoped that this will be avoided by the winnings which are now being driven farther to the south, and below the fault at the mouth of the river Blyth.

This area is held under the same lease as the Cambois undersea coal, and the pillars have been removed in the ordinary way up to the 360 feet limit of cover prescribed by the licence varying the terms of the original lease. Permission to extend the total extraction of the seam, which is here about 3 feet thick, farther seaward, up to a limit of cover of 300 feet, has recently been given, provided that all workings between the 360 and 300 feet lines of cover, are made on the longwall system and are securely packed.

The remaining area to the south (Newsham), held by this company, is now being entered upon from the Mill pit in the Low Main seam. The seam is here 3 feet thick, and lies at a depth of about 590 feet below high-water mark.

The foreshore here (as at Cambois) is the property of the adjacent landowner, and of considerable extent. Both the Yard seam (2¾ feet) and the Low Main (3 to 3¾ feet) have been entirely worked out under a great part of this area, the amount of cover over the Yard seam being only about 240 feet. The surface-deposits were, however, capable of being proved by boring, and were found to consist of from 40 to 55 feet of Boulder-clay.

The limit of cover up to which the whole of the coal may be removed, under the Newsham lease, is fixed at 300 feet, and there are provisions for exploring in advance of longwall workings and leaving barriers against the main roads of any bord-and-pillar workings.

Broomhill Collieries.—The only other undersea-workings, which have been undertaken up to the present time, are those from the pits of the Broomhill Collieries Limited, in the district of the river Coquet.

At Newbrough colliery, winnings have been driven seaward in the Princess seam for a distance of about 2,400 feet from high-water mark. The cover at the last-named point is about 480 feet, the seam (2 feet 7 inches thick) is dipping seaward, and the cover at the face is about 420 feet thick.

About 1½ miles farther south, a commencement has been made to drive exploring places seaward in the Duke seam, near the southern extremity of the workings in that seam from Broomhill colliery. The cover here is about 240 feet thick, at present; and the seam is about 4 feet thick, and is being split into two portions by a gradually thickening band.

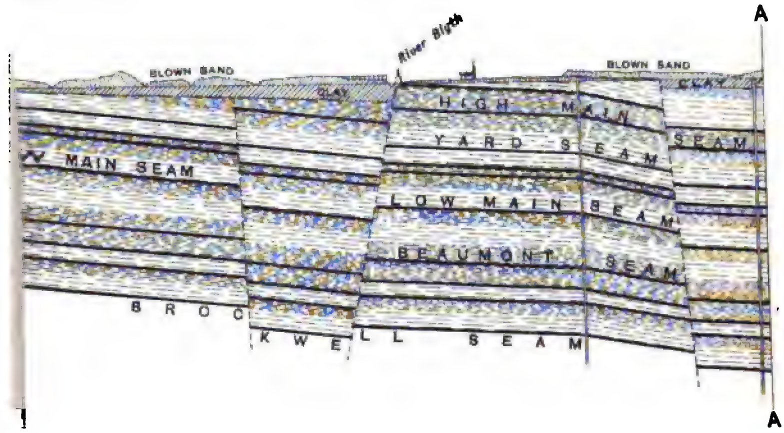
Unworked Areas.—It may here, perhaps, not be out of place to add some remarks as to the unworked portions of the field.

South of the Newsham area, towards Hartley, there will no doubt be coal, which will be found under a workable cover, consisting, probably, of a comparatively small tract of the Low Main seam and much more extended areas of the lower seams.

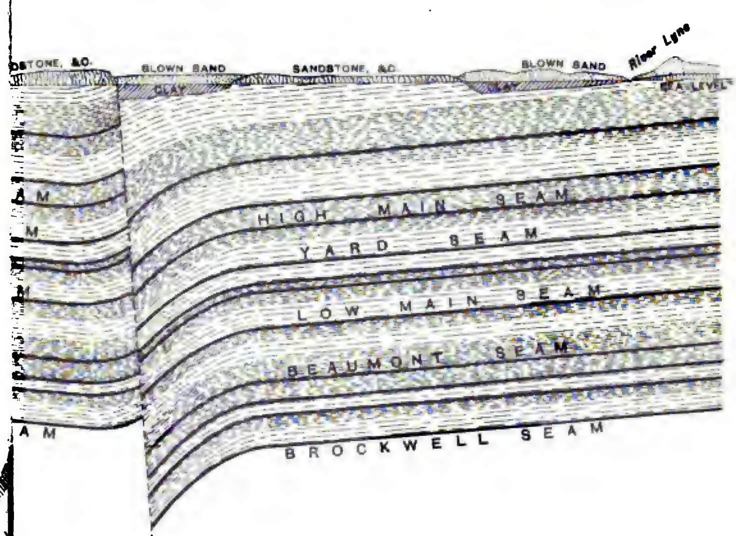
Possibly, from Hartley southward, the lower seams may from a further reserve of workable undersea coal.

FIG. 2.

THE COAST FROM HARTLEY TO LYNEMOUTH.



COAST FROM HARTLEY TO LYNEMOUTH (CONTINUED).



Horizontal Scale, 1 Mile to 1 Inch.

Vertical Scale, 600 Feet to 1 Inch.

North of the river Wansbeck, the area of workable coal will, probably, depend chiefly on the exact course of the synclinal axis, and the farther it trends seaward, the greater will be the extension of the field in that direction.

It appears, however, to be possible that the easterly rise may not continue indefinitely seaward and that an anticline may be met with, which will still further prolong the extension of the field eastward. In any case, it seems certain that a very large reserve of coal is contained in the undersea area under consideration.

Conclusion.—In conclusion, it may be of interest to call attention to the fact that the operations, which have been described above, form a record of the progress which has been made, in this vicinity, in the working of coal lying at moderate depths under the sea. Experience has been gained since 1872, when it was considered necessary to leave unworked a large proportion of a seam with a cover of more than 600 feet, which has gradually admitted of the lowering of the limit to, in some instances, less than 300 feet, and has resulted in the working of large quantities of coal which it was at one time thought would be lost.

The writer hopes that the results of this experience may possibly be of use to others, although, at the same time, he would point out that a careful consideration of the local circumstances is of great value in fixing the conditions under which undersea operations are to be carried on.

Mr. J. G. Weeks (Bedlington) said that Mr. Forster's paper contained a clear and succinct account of under-sea workings, and it would be a valuable addition to the *Transactions*, as it dealt with every detail. The paper referred to the thinning out of the clay westward from the sea, until at a line between Bebside and Choppington stations it ran out, and the rock came next to the surface. He (Mr. Weeks) said that the line would run about 4 miles west from the sea-coast. The clay thinned away from 60 or 80 feet to practically nothing, and ordinary sandstone formed the surface with a soil-cover. Mr. Forster did not give the size of the Wansbeck fault; he (Mr. Weeks) had recently proved it, and was somewhat surprised to find that it amounted to 636 feet

at a point between the Bedlington and Ashington collieries, and he had proved it within 200 feet of the workings on either side.

Mr. T. FORSTER BROWN (Cardiff) stated that Mr. Forster's paper appeared to form a complete record of the coal-workings under the sea in Northumberland so far as they had gone. He (Mr. Forster Brown), as the Crown chief mineral inspector, had inspected these workings, from time to time, and he thought it clear that a sound principle to begin with in working longwall in a seam under the sea, unless the depth was exceedingly great, was to have the whole of the space packed thoroughly, so as to avoid any question of endangering the coal, either under the land- or sea-workings. He would be glad if Mr. Forster would explain his grounds for supposing that there might be another anticlinal axis seaward, and beyond that there might be a dip seaward which might extend the coal-area. He entirely agreed with Mr. Forster that after all, in working an unknown area, where they had no surface to guide them, and could only obtain their knowledge and experience by underground operations, it became a question of circumstances, as time went on, how to deal with any particular difficulty that might arise under the sea.

Mr. H. M. CADELL (Grange, Bo'ness) said that he was interested to some extent in submarine mining in the Bo'ness coal-field, on the Firth of Forth, although the workings did not extend so far as those described in Mr. Forster's paper. He had previously communicated a paper upon the workings at Bridgeness colliery,* but since that paper was written the Main seam had cropped out towards the west against the sea-bottom at a depth of 500 feet. They did not experience any inconvenience, although they were at first a little alarmed and disappointed at striking the sea-bottom so soon. Several glaciated stones fell out, showing that they had got into Boulder-clay. The Firth of Forth was now only about 20 feet deep at that point, and there must have been a deep trough in former times, which had cut off the outcrop of the seams in that direction. Three or four seams were worked in the section, and they all cropped against the bottom of the Boulder-clay. The deepest place where this had been reached was 500 feet, and that was only ¼ mile below low-water mark. The centre of the Firth of Forth was an old valley eroded prin-

* *Trans. Inst. M.E.*, 1897, vol. xiv., page 237.

cipally during the Glacial period, and it was not probable that such a thing would be met with in this district, because these deep troughs were only found in places where there had been old river and valley-glaciers. It would be a useful thing at the extreme end of the workings to put a bore upwards to the bottom of the Boulder-clay in order to ascertain its depth, and the hole could be easily plugged. One part of the workings at Bridgeness struck the bottom at a depth of 170 feet, and the Boulder-clay being very strong formed such an excellent roof that the seam had been worked under it for many feet. A large glacial stone then rolled out and nearly killed a man, and the workings were thereupon stopped. He merely mentioned this as an example of how excellent a roof Boulder-clay could form. If it was possible to prove that the whole of the ground was formed of Boulder-clay, it would be quite safe to work out all the coal. One great advantage of submarine workings was that there was no surface-damage to pay for, and this often meant the difference between profit and loss at many collieries. Of course the farther out they went under the North Sea, the less would be the cost of surface-damage in proportion to the area of the workings. It was not likely that there would be much sand out at sea; the sediment from the shore was carried out as fine mud, and the farther seaward they got the roof should be all the tighter. He would like to know whether there was much water to contend with in the Northumberland workings; under the Firth of Forth, there was not; and down to a depth of 600 feet the water was so small in quantity that it could be dealt with by a Moore hydraulic pump with a ram 8 inches in diameter. The bed of overlying clay kept the workings remarkably watertight.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that there were two points to have in view:—(1) The danger of losing the workings by water, and (2) the danger of loss of life. The first danger would usually declare itself before the second, although that had not always been the case, as was shewn in the accident at the Workington collieries, where there was considerable loss of life from working the undersea coal. There were four factors to consider:—(1) The thickness of the coal-seam; (2) the thickness of the solid strata above the coal; (3) the thickness of the alluvium; and (4) the depth of water. Of these factors, only the thickness of coal and the depth of water were usually

ascertained. It was difficult to ascertain the proportion of alluvium and solid strata. Mr. Cadell's suggestion that a bore-hole might be put upward from below would test this proportion. Mr. Forster's paper was a useful contribution to the study of a question which would become more important in the near future, and it shewed clearly what had been done with safety.

Mr. J. GERRARD (H.M. Inspector of Mines, Manchester) offered for consideration an additional factor, which might be of interest; that was the nature of the strata overlying the seam of coal, the thickness of the beds of bind or shale, and the thickness of the beds of sandstone. In connection with questions of subsidence, much depended upon whether there were extremely thick beds of sandstone or moderately thick beds of shale or bind.

Mr. W. H. PICKERING (H.M. Inspector of Mines, Doncaster) hoped that Mr. Forster would supplement his paper by giving the conclusions at which he might have arrived as to the best method of working undersea. At Cambois colliery, the bord-and-pillar method was adopted and large goaves were formed, and he presumed that there would be heavy falls. At another pit, only long-wall was worked, and they built tight packing. This appeared on the face of it to be the safer condition, but without knowing all the circumstances one could not decide. The conclusions at which Mr. Forster might have arrived on the subject would be of interest.

Mr. R. E. ORNSBY (Seaton Delaval) said that it would no doubt be necessary at no very distant date for the adjoining colliery under his own charge that he should consider the question of undersea working. Unfortunately they were not so well placed as at Cowpen colliery, as the seams at Hartley colliery rose to the eastward. With respect to the strata between the Yard and Low Main seams, his experience was similar to that at Cowpen. The Yard seam to the dip was standing full of water, some pillars were wrought, about 200 feet below in the Low Main seam (with a thickness of 6 to 7 feet of coal), and although they were afraid of the water, they practically got none at all in the Low Main seam, notwithstanding that there were heavy falls in the goaf.

Mr. C. C. LEACH (Seghill) asked whether there were any bottom feeders, and, if so, were they salt?

The CHAIRMAN (Mr. J. S. Dixon) said that, in his own experience, he had dealt with workings not under the sea, but under inland waters and under wastes containing water; and as to the expediency of leaving a portion of the solid coal, his view was that the less coal they left the better, but that the waste should be thoroughly stowed or packed. In the part of the country with which he was connected, leaving in a piece of coal led to dislocations; and these ultimately came to the surface and created cracks through which water might percolate. With a cover of 70 or 80 feet of Boulder-clay, great liberties could be taken when working seams at moderate depths. In many cases, seams had been worked, 3 feet thick, under wastes lying full of water, 200 feet above, and through every break of the strata small feeders of water were got; but in the course of a few weeks these were filled up by the swelling of the fire-clay and shales, and the strata behind the face became impervious, whereas the strata at the face gave off a little water. Where there was mud in the bottom of a river, or even sand, this very often filled up the interstices made by the subsidence of the coal-working. If it could be proved by boring in the sea that the clay extended over the whole area of the coal-workings, he thought that probably the coal might be worked even nearer the surface than indicated by Mr. Forster.

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) said that it appeared to him that longwall working in panels would be the preferable system of working coal-seams under the sea, where systematic packing, or the complete filling of the goaf could be carried on in the workings left behind the face. It seemed to be severely tempting providence to work by pillar-and-stall, where no packing is done, the pillar robbed, and large falls of roof of unknown height frequently occur. Although soundings are taken giving the depth of water, showing the amount of strata between the sea and the seam, yet there are seas with a shifting bottom, a circumstance which in the cases quoted, does not appear to have been taken into consideration. Whether the German Ocean at these points is one of that kind or not, he could not say, but if it is, the soundings are entirely unreliable.

Mr. M. W. PARRINGTON (Wearmouth Colliery) wrote that, if anything could have made Mr. Forster's paper more useful to those interested in the Great Northern coal-field, it would have

been its extension to the whole coast-line of the field from the mouth of the Coquet to Hartlepool; and he believed that no one had a better general knowledge than Mr. Forster of the conditions met with south of the Tyne. Perhaps, however, it would have been premature to have so extended it while the great coast-winnings at Dawdon, Easington and Horden are still incomplete. These winnings are far enough advanced to have proved the thickness of the Magnesian Limestone, and (by boring) the thickness of the underlying sand; and they show that the bottom of the sand has a generally increasing depth, below sea-level, to the south, as far as proved. It had also been proved, at very great cost to the proprietors of these winnings, that the sea had direct communication inland, through the limestone-fissures, and that it was only necessary to exhaust the fresh-water feeders to get sea-water, pure and simple. This communication will doubtless become more remote as the distance from the coast increases, but that it exists to some extent wherever the limestone is below sea-level seems proved by the fact that the surface of the water in the Magnesian Limestone will come to rest at or about that level. He (Mr. Parrington) had made these remarks with the view of showing that the workings of the deep east-coast collieries of Durham are practically, where not actually, under the sea.

He (Mr. Parrington) believed that in only one case had any considerable area of coal been worked at a less depth from the bottom of the Yellow Sand (where below sea-level) than those from the sea-bottom given by Mr. Forster, and, in that case, large areas of a 4 feet seam were extracted by a modified system of longwall at a depth varying from 330 feet to an estimated depth of 200 feet. Pillars were formed at the small estimated depth of between 40 and 50 feet; but when, under stress of circumstances, an ill-advised attempt was made to extract these pillars, the natural result followed.

Some of Mr. Forster's remarks point to the great desirability of a thorough examination of the sea-bed. It was difficult to believe that loose sand lies to any great depth on a sloping bottom; and, therefore, he (Mr. Parrington) ventured to think that, with proper appliances, samples of the original formation might be obtained at intervals along the coast, and to a distance of 2 miles out or even more. The cost, when divided among all parties interested, would not be very serious.

He hoped that Mr. Forster might be able, at no remote date, to supplement his valuable paper with one on the "Undersea Coal of the Durham Coast."

Mr. H. S. POOLE (Halifax, Nova Scotia) wrote that in Nova Scotia a consideration of undersea workings elsewhere, the depth of rock-cover between the water and the workings under varied conditions required by regulations, the methods of operating, and the precautions taken against irruptions of water from the sea-bed, were matters of great interest, as in that province there are large coal-fields lying under the sea. These leases are held under conditions differing from those described by Mr. T. E. Forster, in his paper on the "Undersea Coal of the Northumberland Coast";* and in that of Mr. A. A. Atkinson on "Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales."† No official in Nova Scotia is empowered to modify the terms of leases to suit local conditions, one set form being supplied and held applicable to all for a given period; and legislation regulates all restrictions. In all but a few early grants of land, the Crown reserved its rights to one or more of the economic minerals, issuing the grants as applied for without any pre-arranged plans. So it has been with the minerals reserved: applicants for rights to search or work, and for leases, exercised their choice of location within certain limits as they pleased, and without regard to the convenience of approach and general working, or the best interests of the whole coal-field. This system applied to all submarine as well as subterranean holdings.

The writer, when acting as an inspector of mines, foresaw that a time would come when special legislation for submarine operations would be necessary. In his report for 1877, he suggested precautionary measures, and, later on, he drafted the clauses relating to submarine areas incorporated in the Mines Regulation Act of the following session, and these have since then remained unchanged on the statutes. These regulations antedate by some eight years some of the recommendations of the New South Wales Commission of 1886, as follows:—"The Commission are fully aware that, so far as they know, no restrictions such as those indicated have been as yet considered necessary

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 421.

† *Ibid.*, 1902, vol. xxiii., page 622.

in Britain or her colonies."* The restrictions imposed, in 1877, in Nova Scotia, although not so exhaustive as those of New South Wales, met the requirements of the time. Workings below 500 feet of rock-cover are left untrammelled, all under a less cover are restricted, and those under less than 180 feet are totally debarred, except for approaches, which may be carried on with 100 feet of overlying strata. These figures have, somehow locally, become regarded as allowing so safe a margin that applications have been made to the Legislature to have them reduced on the plea that so much coal is locked up and lost, but so far without success.

Up to the present time, the only extensive operations under the sea have been made at the mouth of Sydney Harbour, in the Main seam, dipping 1 in 12. There, under a cover of 800 feet, pillars have been robbed, and longwall workings conducted where the depth was 1,000 feet, without the seepage of any salt-water. But at shallower depths, some had been found: the deepest at about 400 feet, where a steepening of the measures was approached, and a lype may have given access to a small feeder of sea-water. The Coal-measures of Cape Breton are for the most part sandstones in which open "backs" have been encountered.

The sinking of the Princess pit, 600 feet away from the cliffs, tapped a feeder of 400 gallons a minute, and this was tubbed back. Over the workings, the deepest soundings give about 40 feet of water with a sand-bottom, which may or may not overlie a deposit of till, but no attempt has been made to determine its presence. Mr. A. A. Atkinson referred to the condition of the Sydney mines workings some years ago.† Now, the dip-plane is 6,600 feet long, the distant submarine workings extending 3,400 feet from the point of Cranberry Head, where, at a depth of 1,000 feet, the pillars are increased in dimensions to 33 feet by 132 feet. The Sydney Main seam averages over 5 feet 3 inches and in parts is 6 feet thick, dipping 1 in 12 towards the open sea. The pillars to the deep have been successfully wrought, even in crushed districts.

In the overlying Lloyd's Cove seam, a dip-plane is now being driven beyond Cranberry Head, close within the permitted limit of cover. These operations are in the Cape Breton coal-field, which has a sea-front of 32 miles.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 636.

† *Ibid.*, 1902, vol. xxiii., page 647.

On the western side of the island, the Coal-measures extend nearly 40 miles, but on parts of the coast Lower Carboniferous rocks come to the surface, and it is evident that the submarine portion of the Inverness coal-field is, although of importance, comparatively less extensive. The dip is steep from the shore under the waters of the Gulf of St. Lawrence, carrying the coal-seams rapidly beyond a working depth.

The very thorough investigation of the subject of operating coal-mines under water by the New South Wales Commission and the paper by Mr. A. A. Atkinson come opportunely for the conditions now under review in Nova Scotia, where off the coast of Cape Breton, there are large areas of thick coal-seams lying under light and moderate depth of cover, temptingly near the shore, and extending seaward for several miles. In parts undulating with low dips, the outcrops of the seams enter the sea and necessarily large districts of valuable coal will have to be sacrificed to considerations of safety. The question at issue is not at what depths working can be conducted without anxiety, or at what additional depth with confidence, but how thin may be the solid cover and how large may be the proportion removed. The rapidly growing coal-trade is already looking to these sea-areas for the speedy establishment of pits so laid out as ultimately to win the extreme limits that ventilation, mechanical appliances and competition-cost may permit. The New South Wales Commission advisedly places importance on the condition of the sea-bottom, the presence or not of clay; but off Cape Breton nothing is known beyond what the soundings have demonstrated the superficial covering to be, mud, sand or rock. In-shore, where the water is shallowest along the headlands exposed to the full force of easterly storms from the Atlantic Ocean, and to comparatively rapid erosion, there must be a broad strip of ground won by the sea since the close of the Glacial period, on which there may be no bed of clay such as that period left deposited over most of the land. In the work of erosion, the pounding of the sea has been assisted by the disintegrating effect of frost, and the removal of the débris by the shore-current, which flows strongly by from the north. Outside these strips, where no deposits of Glacial drift were left, there is in places no doubt a protective mantle of clay.

The following are the regulations as to working submarine areas:—

52.—(1) In the working of coal or stratified deposits in submarine areas, the following provisions shall apply:—

(*a*) No submarine seam of coal or stratified deposit shall be wrought under a less cover than 180 feet of solid measures: provided that the owner or lessee of any such area may drive passage-ways, to win the mineral to be wrought, under a less cover than 180 feet, but not under less than 100 feet of solid measures;

(*b*) A barrier of the mineral wrought, of not less than 50 yards, 25 yards on both sides of the boundary-lines of every lease, shall be left unwrought between the workings of every submarine seam;

(*c*) Where there is less than 500 feet of solid measures overlying the seam or stratified deposit wrought, the workings of every such submarine area shall be laid off in districts of an area not greater than ½ square mile, and the barrier enclosing each separate district shall not be less than 30 yards thick, and shall not be pierced by more than three passage-ways having a sectional area not greater than 6 feet by 6 feet;

(*d*) No district shall have its length, when parallel to the general trend of the adjoining shore, greater than 1 mile;

(*e*) A proposed system of working the mineral in each submarine area shall, before work is commenced, be submitted to and approved of by the inspector; and no change shall be made in such approved system without the written sanction of the inspector;

(*f*) The opening of a new level or lift in a mine already working in a submarine area shall be deemed the commencement of a new winning within the meaning of this section.

(2) The owner, agent or manager of any mine to which this section applies, who contravenes or fails to comply with any provision of this section, shall each be liable to a penalty not exceeding 1,000 dollars [£200], and if the offence complained of is continued or repeated after a written notice has been given by the inspector to such owner, agent or manager of any such offence having been committed, the Supreme Court or a judge thereof, whether any other proceedings have or have not been taken, may, upon application by the Attorney-general, prohibit by injunction the working of such mine; provided that the Commissioner may waive or modify any of the provisions of this section, when, on the report of the inspector, it appears to his satisfaction that valuable coal-areas cannot be otherwise wrought or mined. Revised Statutes, c. 8, s. 55; 1896, c. 12, s. 1.

Mr. T. E. Forster, replying to the discussion, said that he would answer the questions raised as to the Boulder-clay. Of course, the difficulty pointed out in the paper was that in this part of the country (it was perhaps different in the Firth of Forth) the clay was so erratic in its thickness. Even if they were to bore a hole from the workings upward to prove the thickness of the clay, they had no guarantee that 300 feet away there was any clay at all. To make the clay-capping of any use in settling the distance, they would have to explore the whole field with bore-holes every here and there, and it was hardly practicable to do that from underground; that was one of the disadvantages of working under the sea, though perhaps the absence of land-drainage might

counter-balance the disadvantages. That, however, was the reason why the distance had been fixed at what might seem a large one to those who were working under the Firth of Forth.

As to the method of working, the paper was meant to be a record of what had been done rather than as a guide to what might be done, and it was not intended to lay down regulations or suggestions as to how to work sea-coal. It had always been the idea here that every place ought to stand by itself under its own conditions. The depth of the sea, the thickness of cover and of alluvium were points to be taken into consideration. The great point was to consider what had already been found practicable in the neighbourhood. In an old coal-field, they could always find instances of one seam being worked under the waste of another, and putting one thing with another they could form a conclusion as to the thickness of strata necessary. They must put a margin of safety: 120 feet in some instances was considered sufficient, while in others this would bring down water. There were no heavy feeders: a certain quantity of water came down in the case of coal worked by bord-and-pillar after the pillars were removed, but this generally ceased after a time, and permanent feeders were very slight. The water was not very salt—only brackish.

As to the methods of working by bord-and-pillar and long-wall, at Cambois colliery, up to 360 feet of cover the whole of the seam, 4 to 4½ feet thick, was worked out by bord-and-pillar. The pillars were taken out, and no packing was put in. The strata did not fall very far up in that district—about 12 or 15 feet—and then it became jammed. Farther south, where the coal was being removed at a depth of 300 feet, the whole of the workings were being packed. Regarding the strata overlying the seams, it was pointed out that some information as to the thickness of the different beds might be of interest. As a rule, there were no abnormal thick beds of any one material; there were beds of post, sometimes 60 to 70 feet thick, but they varied very greatly. At Cambois colliery, sandstones formed 57 per cent. of the strata, while within 1 or 2 miles they were only 42 per cent. These were shaft-sections, and the sandstones might be thicker near the shaft in one section than in another.

As to the possible extension of the coal-field farther east-ward, and the reason that an anticline might be met with and the seams dip to the sea: farther south, the beds about New-

castle all dipped in that direction, and at Wallsend they began to rise towards the mouth of the river, and that easterly rise continued for a certain distance along the coast. In Durham, the direction was changed.

Some discussion took place at the last meeting as to working sea-coal, and he made some remarks about the Workington disaster. The account of this disaster seemed to have pursued the subject of undersea coal-mining all over the world, and most engineers were under the impression that it was due to an inburst of the sea. A reference to the report of the discussion in the *Transactions** would show that the workings were holed into an old river-bed. The course of the river-bed was known, and they worked into it, although they had had warnings for some days before that there was danger in front of them; but, like many other people, they wanted the coal, and neglected the necessary precautions.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Forster for his valuable paper.

Mr. C. C. LEACH seconded the resolution, which was cordially approved.

Mr. M. R. KIRBY's paper on "Steam-generation by the Gases from Beehive Coke-ovens" was read as follows:—

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 663.

STEAM-GENERATION BY THE GASES FROM BEEHIVE COKE-OVENS.

By M. R. KIRBY.

Beehive coke-ovens have been used since 1765, when several were working on the Tyne. They have been described by Mr. A. L. Steavenson in his paper on "The Manufacture of Coke in the Newcastle and Durham Districts," read in 1860.* This class of oven was in general use in 1855, when flues and chimneys were added by Mr. A. L. Steavenson, who further improved them in 1860, by placing boilers on the flues and utilizing the heat of the waste-gases for raising steam.

The writer proposes to give a few particulars of the steam-generating plant at the collieries with which he is connected.

One ton of coal, in coking, gives off 6·85 tons of burnt gas, and uses about 6·45 tons of air, a weight about 25 per cent. more than that required for complete combustion. The heat given off during the process is 16,299,000 British thermal units; and, if properly used, it would generate 7½ tons of steam from and at 212° Fahr., but in practice the evaporation is about 1·3 tons. The specific gravity of the burnt gas is about 1·1 and its specific heat is 0·251.

The approximate composition of the coal, coke and gases is given in Table I.

TABLE I.

	Coal.	Coke.	Unburnt Gas.	Burnt Gas.
Carbon (C)	83·0	92·7	68·50	—
Carbon dioxide (CO_2)	—	—	—	14·68
Water (H_2O)	7·3	—	18·25	5·92
Hydrogen (H)	3·7	—	9·25	—
Oxygen (O)	—	—	—	0·38
Nitrogen (N_2)	1·0	—	2·50	75·42
Sulphur (S)	0·6	—	1·50	—
Sulphurous Acid (SO_2)	—	—	—	0·17
Ash	4·4	7·3	—	—

* *Trans. N.E. Inst.*, vol. viii., page 109; and vol. ix., page 35.

At Browney, South Brancepeth and Tursdale collieries, the beehive coke-ovens are 11½ feet in diameter by 7 feet high inside. The coal coked per oven per fortnight is about 22 tons, making the rate of coking 146·6 pounds of coal per oven per hour. The gas given off is about 1,004 pounds per hour, and the heat is about 1,066,660 British thermal units per hour per oven.

TABLE II.—BOILER-PERFORMANCES AT BROWNEY, SOUTH BRANCEPETH AND TURSDALE COLLIERIES.

	Browney.	Tursdale.	South Brancepeth.
Number of boilers	6	8	10
Heating surface, square feet	8,130	8,530	7,391
Number of beehive coke-ovens	262	223	246
Heating surface per oven, square feet ...	31	38	30
Working pressure of boilers, per square inch, pounds	50	40	40
Temperature of feed-water, Fahr. degrees ..	120	180	177
Evaporation of water per hour, pounds ...	45,860	38,000	31.000
Evaporation of water per oven per hour, pounds	175	170	126
Evaporation of water per square foot of heating surface per hour, pounds ..	5·64	4·45	4·19
British thermal units used per oven per hour	189,900	172,550	128,268
Efficiency, per cent.	17·8	16·1	12

Table II. gives particulars of the boiler-performances at these collieries. It will be seen that the plant at Browney colliery is much more efficient than at any of the others; and this is probably due to the fact that the boilers are of more modern design, comprizing 2 Galloway, 3 five-flued and 1 Lancashire boiler. Tursdale colliery comes next, with 6 Lancashire and Galloway, and 2 egg-ended boilers. While at South Brancepeth colliery, where the efficiency is lowest, there are 2 Lancashire, 1 Galloway, 2 French, and 5 egg-ended boilers.

A more complete series of tests was made on No. 2 boiler at South Brancepeth colliery in July and August, 1902, and the results are recorded in Table III. The temperatures in the flues were measured with a Siemens pyrometer, and the water with a Guest-and-Chrimes water-meter, which was repaired and tested previous to the experiments. The boiler was scaled before the tests were begun.

TABLE III.—TEST OF NO. 2 BOILER AT SOUTH BRANCEPETH COLLIERIES, 1902.

Type of boiler, Lancashire, 30 feet long and 8 feet in diameter, fitted with cross-tubes in the flues.

Heating surface, square feet	1,100
Number of coke-ovens firing this boiler	25
Steam-pressure, pounds per square inch	40
Temperature of feed-water, Fahr. degrees	177
Dimensions of chimney *: height, feet	75
,, ,, side of inside square, feet...	9
Heating surface of boiler per oven, square feet	44

* This chimney will not draw from more than 25 coke-ovens.

1902. July and August.	Temperature.		Draught of Boiler Measured in Water-column.		Water evaporated per Hour.
	At Front of Boiler.	In Flues at Back.	Front.	Back.	
	Degs. Fahr.	Degs. Fahr.	Inch.	Inch.	Pounds.
Monday	1,412	322	—	—	2,700
Tuesday	1,801	488	0·15	0·40	3,330
Wednesday	2,048	465	0·15	0·40	4,630
Thursday	2,212	440	0·15	0·45	4,990
Friday	2,390	467	0·15	0·55	4,990
Monday	2,092	552	0·15	0·50	3,760
Tuesday	2,087	352	0·15	0·45	4,750
Wednesday	1,962	484	0·15	0·50	4,990
Thursday	2,474	484	0·15	0·55	4,770
Friday	2,346	482	0·15	0·55	—

The average evaporation of water per oven per hour was 165 pounds, and 3·9 pounds per square foot of heating surface of boiler per hour. The efficiency of the boiler is about 16 per cent. Neglecting the loss due to radiation from the boiler, which is comparatively small, the other losses are shown in Table IV.

TABLE IV.—DISTRIBUTION OF HEAT PRODUCED FROM COKE-OVENS.

	Heat per Hour from 1 Oven.	
	British Thermal Units.	Per Cent.
Loss: By radiation from coke-ovens, flues, etc. ...	794,244	74·4
By heat in gases at chimney	100,800	9·5
Total loss	895,044	83·9
Utilized: Heat used in raising steam	171,616	16·1
Total heat accounted for	1,066,660	100·0

It would seem to be possible to reduce largely the loss due to radiation from the coke-ovens and flues, by covering them thickly with sand or masonry. But, assuming this loss to be inevitable, the writer considers that in Lancashire and similar boilers about 30 square feet of heating surface should be allowed per oven, in order to secure the full value of the boiler; and, consequently, 37 ovens should be applied to a boiler similar to that tested at South Brancepeth colliery.

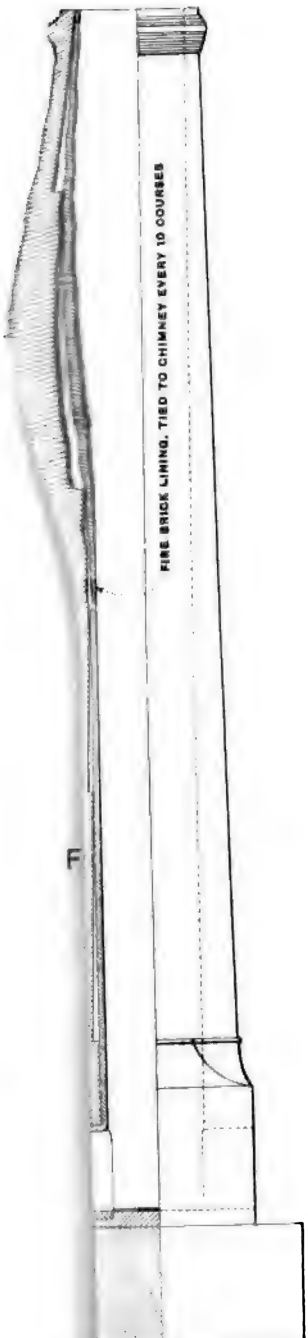
In the writer's experience, in order to draw the gases from this number of ovens through a Lancashire boiler, a chimney 100 feet high and having an area of 1 foot to 1·25 square feet per oven is necessary.

Figs. 1, 2, 3 and 4 (Plate XI.) give the details of the seating of a Lancashire boiler which is being put down at Tursdale colliery, with 1,040 square feet of heating surface. It is intended to fire this boiler with the gases from 40 beehive coke-ovens. A bye-pass flue is provided for use when the boiler is laid off, and provision is also made for hand-firing. The chimney is shown in Figs. 5, 6 and 7, and the dampers in Figs. 8 and 9 (Plate XI.).

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Kirby for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. C. C. LEACH read the following paper on a "Corliss-engined Fan at Seghill Colliery":—



5.—Section and
de Elevation.

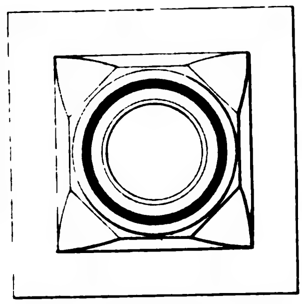


Fig. 7.—Plan.

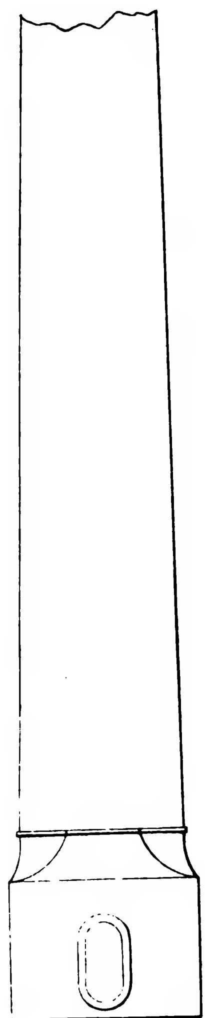


Fig. 6.
Front Elevation.

CORLISS-ENGINED FAN AT SEGHILL COLLIERY.*

By C. C. LEACH.

The Corliss-engined fan at Seghill colliery has now been running for 10 years, and the following particulars may be of interest.

Engine.—The valve-gear of the engine has required neither repairs nor adjustment: two of the trip-gear steel-plates have been turned round, as the edges were slightly worn and occasionally failed to open the valves; but this did not affect the speed of the engine. Two sets of piston-rings have been put in, one of them only a few weeks ago, and one set of plates for the metallic packing of the piston-rod has been replaced. The cylinder is hardly worn.

The engine has worked absolutely satisfactorily, and apparently will continue to do so for many years without overhauling; and the continuous work through day and night is equal to 30 years work at the rate of one shift a day.

Ventilation.—The following measurements of the air have been made so as to compare what the fan is now doing, with what it was doing when tested in 1893, and also to shew the improvement in the airways in the pit.

Tests have also been made to shew the effect of cleading the fan-drift, so as to turn the air into the inlet-opening of the fan and to lessen the air-eddies; and also of cleading the fan-race, at the end where the fan runs downward into it.

If the airways had remained in the same condition as they were in 1893, it would have required 2·42 inches of water-gauge to produce 131,004 cubic feet of air per minute instead of 0·96 inch, and 5·81 inches of water-gauge for 208,170 cubic feet of air per minute instead of 2·17 inches of water-gauge.

* *Trans. Inst. M.E.*, 1893, vol. vi., page 48.

TABLE I.—FAN-EXPERIMENTS MADE ON JULY 19TH, 1902.

Approximate Speed of Fan in Revolutions per Minute.	40		
Conditions of Experiment.	A	B	C
Condition of the mine	Ordinary	Ordinary	Ordinary
Revolutions of fan per minute	40·25	38·01	40·90
Revolution of anemometer, per minute	779	706	743
Velocity of air per minute, feet	771	705	736
Volume of air per minute, cubic feet	140,376	128,310	133,952
Water-gauge in drift, inches	1·02	1·00	1·00
Barometer in engine-house, inches	29·80	29·79	29·78
Temperatures: air, wet bulb, degrees	50·5	51·5	54·5
,, ,, dry bulb, degrees	54·2	59·5	62·0
,, drift, wet bulb, degrees ...	58·0	58·0	58·0
,, ,, dry bulb, degrees ...	58·0	58·0	58·0
Boiler-pressure per square inch, pounds	100	100	100
Mean pressure of indicator-diagrams per square inch, pounds	29·95	27·08	29·23
Indicated power of engine, horsepower ...	43·29	36·96	42·93
Power utilized in air, horsepower	22·56	20·22	21·11
Plant-efficiency, per cent.	52·11	54·71	49·17

Approximate Speed of Fan in Revolutions per Minute.	60		
Conditions of Experiment.	A	B	C
Condition of the mine	Ordinary	Ordinary	Ordinary
Revolutions of fan per minute	59·93	59·96	59·44
Revolution of anemometer, per minute	1,157	1,111	1,149
Velocity of air per minute, feet	1,134	1,088	1,126
Volume of air per minute, cubic feet	206,388	198,071	205,932
Water-gauge in drift, inches	2·25	2·15	2·15
Barometer in engine-house, inches	29·79	29·79	29·78
Temperatures: air, wet bulb, degrees	51·2	52·5	54·5
,, ,, dry bulb, degrees	55·5	59·0	62·0
,, drift, wet bulb, degrees... ...	57·5	57·5	57·5
,, ,, dry bulb, degrees	58·0	58·0	58·0
Boiler-pressure per square inch, pounds ...	100	100	100
Mean pressure of indicator-diagrams per square inch, pounds	64·02	60·15	62·75
Indicated power of engine, horsepower	137·77	129·51	133·94
Power utilized in air, horsepower	73·17	67·10	69·77
Plant-efficiency, per cent.	53·11	51·81	52·09

Reference:– A, cleadings in fan-drift and on fan-race; B, cleading only in fan-drift; C, without any cleading, as in 1893.

The increase in the volume of air and the decrease in the water-gauge is due to improvements in the shafts and airways, namely:—The John (downcast) shaft has been widened from a diameter of 8½ feet to 12 feet, for a length of 300 feet to the Yard seam, the wooden guides have been replaced by steel-rail guides, longer cages are used, and a steam-pipe, 10 inches in diameter, has been taken out of this shaft for a length of 456 feet.

In the Engine (downcast) shaft, 11½ feet in diameter, the brattice-division has been removed from top to bottom for a length of 456 feet, and 4 cages and wooden guides have been replaced by 2 big cages and steel-rail guides.

TABLE II.—THE FAN-EXPERIMENTS OF 1893 ARE COMPARED WITH THOSE OF 1902, BOTH SERIES BEING REDUCED TO SPEEDS OF 40 AND 60 REVOLUTIONS PER MINUTE.

Revolutions of Fan per Minute.	40			
Conditions of Experiment.	A	B	C	C_1
Date of Experiment.	1902.	1902.	1902.	1893.
Volume of air per minute, cubic feet ...	139,777	135,027	131,004	88,400
Water-gauge in fan-drift, inches	1·01	1·11	0·96	1·10
Indicated power of engine, horsepower* ...	43·29	36·96	42·93	29·61
Equivalent orifice of mine, square feet ..	52·44	48·94	50·04	31·44

Revolutions of Fan per Minute.	60			
Conditions of Experiment.	A	B	C	C_1
Date of Experiment.	1902.	1902.	19[illegible]	1893.
Volume of air per minute, cubic feet ...	206,630	198,207	208,170	134,000
Water-gauge in fan-drift, inches	2·26	2·16	2·17	2·42
Indicated power of engine, horsepower* ...	137·77	129·51	133·94	96·11
Equivalent orifice of mine, square feet ...	51·65	50·51	52·52	32·26

* Not corrected.

The return and intake airways have also been improved, and in some cases doubled, and larger openings have been made into the upcast shaft, which is 11 feet in diameter.

In 1893, there were 10 main splits of air, with a total length of 96,000 feet, and in 1902, there were 12 main splits with a length of 163,000 feet.

Mr. T. H. BAILEY (Birmingham) said that the members were indebted to Mr. Leach for going so minutely into the particulars which were contained in the tables accompanying his paper, as they enabled others to see some of the mistakes and difficulties under which Mr. Leach had been labouring. He asked what was the area of the shaft, of the fan-drift, and of the opening from the shaft into the fan-drift.

Mr. C. L. WATSON (New Tredegar) said that at the Powell Duffryn collieries, South Wales, several fans, dealing with very large quantities of air and mostly of the Walker-Guibal type, were in use, driven by Corliss-valved engines. The engines in each case were compound condensing, and very good results had been obtained from the Corliss valves. All the newer engines, including the winding-engines at their new colliery at Bargoed, which were compound with four cylinders, were being fitted with Corliss valves and expansion-gear.

Mr. J. A. G. Ross (Newcastle-upon-Tyne) said that one advantage of the Corliss valve was that it was so very susceptible: it was so delicate that the governor acting upon it cut off steam in proportion to the work done, and if at any instant there was a sudden demand for work they could instantly raise full steam. A Corliss engine was erected at the Elswick engine-works, about 30 years ago, and it had always worked satisfactorily. The Corliss valve worked economically and with little friction; and the trip-gear was delicate, and worked with the slightest movement.

The CHAIRMAN (Mr. J. S. Dixon) remarked that he had no doubt that the enlargement in the airways had been of considerable advantage. The old theory of ventilation was summed up in the words "big airways."

Mr. C. C. LEACH said that the paper was really a continuation of one read when the fan was started some years ago.* The fan-drift had an area of 191 square feet, and the openings into the shaft were as large as they could be made.

Mr. C. H. INNES (Newcastle-upon-Tyne) wrote that he had read with much interest Mr. Leach's paper on the Seghill fan: the tests had evidently been made with care, and were of scientific as well as practical value. The accuracy of the tests was shewn by the fact that in each pair of tests, A, B and C, the equivalent orifice was practically constant, and the discharge in cubic feet per minute was very nearly proportional to the revolutions; for example, in the two tests A, it was 3,509 by revolutions, and 3,439 by revolutions. The water-gauge was also very nearly proportional to the square of the revolutions, thus in test A it was

* *Trans. Inst. M.E.*, 1893, vol. vi., page 48.

revolutions squared divided by 1,568 and revolutions squared divided by 1,600. Under these circumstances, he (Mr. Innes) thought it a great pity that details were omitted that should, where possible, be given for every fan-test. In the first place, the leading dimensions of the fan should be given, the diameter of the wheel, the diameter and number of inlets, the breadths at the internal and the external radii, and the angles made by the vanes with the tangents at the inner and outer circumferences; the dimensions of the diffuser, if any, and the sections of the volute by 4 planes at right angles, the first being taken by a plane passing through the axis of 90 degrees from the beak of the volute; and a drawing of the fan should also have been given. The position of the water-gauge should also be stated, and whether its end was turned like that of a Pitot tube, in a direction opposite to that of the air-current, or whether it was placed at right angles to it. Messrs. Heenan & Gilbert's tests with a fan, published some years ago,* showed the importance of the tip given to the water-gauge. The manner of measuring the discharge should be fully explained and illustrated by a drawing, showing how the fan-drift or the top of the chimney was divided into suitable areas. It should also be stated whether the fan was driven direct or otherwise. Had Mr. Leach supplied this information it would have increased the value of the tests. It was strange that the mechanical efficiencies at 60 revolutions were on the average so very little better than those at 40. The efficiency of an engine increased with the mean pressure, while that of the fan remained constant for a given equivalent orifice, so that the combined efficiency should increase.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Leach for his valuable paper.

Mr. BAILEY seconded the resolution, which was cordially approved.

Mr. W. BLAKEMORE's paper on "The Fernie Explosion," was read as follows:—

* *Minutes of Proceedings of the Institution of Civil Engineers*, 1896, vol. cxxiii., pages 272-294.

THE FERNIE EXPLOSION.

By W. BLAKEMORE, Montreal.

On May 22nd, 1902, at 7 p.m., an explosion occurred in the Fernie mines of the Crow's Nest Pass Coal Company, resulting in the death of 130 men. The first evidence of the explosion was conveyed to the outside world by a roaring noise, and a cloud of dust blown from the mouth of No. 2 mine, and through the roof of the fan-house, situated near by, to an alleged height of 1,000 feet in the air. There was just one blast and then all was still: no flame and no smoke. The roof was blown off the fan-house and the large trap-doors overlying the air-channel were also blown away; this saved the fan, which was not injured in the slightest degree, but continued to revolve as if nothing had happened. In the course of 2 hours, the roof of the fan-house was sufficiently repaired to allow of the fan doing effective work, and a party of rescuers at once made their way into the mine.

At this point it may be interesting to mention that the mine in question is situate upon the southern bank of Coal creek, a mountain-stream which flows into the Elk river, the mine being situate about 5 miles from the river and from the town of Fernie, from which it takes its name. The coal-field is the now well known Crows Nest Pass district, a basin some 40 miles in length by 10 miles in width, containing upwards of twenty seams of high-grade bituminous coking coal. The No. 2 mine, with an output of about 1,500 tons a day, had been in operation for four years, and had worked out an approximate area of 100 acres. The system adopted was bord-and-pillar, the rooms being 20 feet wide and the pillars 30 feet thick, with cross-cuts 20 feet wide driven every 100 feet. The seam worked was 6 feet thick, with a strong sandstone-roof and a hard shale-floor; the coal itself being soft and friable, and yielding not more than 50 per cent.

of coal passing over 1 inch mesh. The mine, being practically free from water, was dry and dusty, and a considerable amount of gas was produced and could generally be detected. The seam dipped at an angle varying from 5 to 20 degrees from the main level, nearly all the workings being to the deep. This description will give some idea of the character of the mine, and will make it easy to follow the description of the explosion.

The first thing which the rescuing party discovered was that the main air-crossings had been blown out. Of these there were two, one at A, and the other at B (Fig. 1, Plate XII.), the one at A being about 1,200 feet from the entrance of the mine and that at B some 300 feet further inbye. It was discovered, in addition to this, that nearly all the air-stoppings alongside the main deep and the main level had been blown out, from which it will at once be observed that the ventilation had been destroyed by the explosion, and that the circulation when the mine was re-entered could only extend from the entrance of No. 2 mine as far as A or B and back to the fan-house.

The work of the rescue-party extended over four weeks; and, at the end of that time, every part of the mine had been visited, and all the bodies recovered except four, which are still in the mine and probably lie buried under débris. With the exceptions noted hereafter, all the bodies were found in the places where the men were known to be at work, death in every instance having been instantaneous. The exception is in the case of workmen, from what is known as the high line or No. 1 district (Fig. 1, Plate XII.), who were rallied by their boss, a young Englishman named Brearley, and led out of the working-places until they came to E, on their way to the exit, when they ran into the after-damp which was rapidly travelling upward from the lower workings, and were overpowered. When found, they were lying together with Brearley at their head, with their lamps in their hands, in the position of men who had just fallen down through suffocation. The number of this party was 22. The other exception, referred to, was in the case of the men from No. 3 mine which is connected with No. 2 mine. These men were working in the eastern section of No. 3 mine, to the number of 24. What happened to them may be best described in the words of one of the survivors, who gave evidence at the inquest, Charles Burrows. He said: —

We were at work, when all at once I felt a peculiar ringing in my ears, and then a pressure as if my head would be burst in. I heard no noise, but the lights went out [all the men in No. 3 mine were working with naked lights]; I knew what it meant, because I had been in an explosion in Nova Scotia, so I shouted and said "Boys, there's been an explosion – let us get out." We all got together and started for the deep and commenced to travel up; at the corner [F] we met the after-damp, but it was not very strong and we continued our way, running, walking, and sometimes crawling, until we got within 50 or 60 feet of the entrance to the mine. The after-damp had been getting stronger, and here it over-powered us; some of the men fell to the ground, I fell and in stretching out my hand to save myself I put it into the dust which lay along the side of the road, and it felt so hot that I thought my hand was burnt, and quickly pulled it away again; I staggered on, and finally fell down within a few feet of the entrance to the mine, and I knew no more until I found myself outside.

The whole of these men were rescued by a party from the outside, having made their way so near to the entrance of the mine that they could be seen. The evidence of Charles Burrows, which was confirmed by others of his fellows, is extremely interesting as illustrating the effect of the explosion upon the men themselves, and upon the coal-dust, which at a distance of at least 3,000 feet from the supposed origin of the explosion, and in a part of the mine where there was considerable water and no gas, was found to be heated to the point of almost burning the men. This fact is well worth study.

All the other men, who were killed, were found at or near to their working-places, and most of them had not moved. The working-places, generally speaking, are shown in Fig. 1 (Plate XII.) comprizing No. 3 mine, west side; and No. 2 mine, No. 2 district, No. 3 district, MacDonald level and Beaver level, upwards of 100 men being recovered from these places, the total number of men in the mine being 154.

The evidence showed that, with few exceptions, the men were killed by after-damp, the exceptions being somewhat peculiar, and clearly illustrating the fact that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the main explosion. This is shown by the fact that at G, in No. 1 room of the MacDonald level, at H, near the face of the MacDonald level, and at I, in No. 1 machine-room, the bodies of men were found terribly mutilated, whilst in the intervening working-places the bodies were unmarked and indicated that the victims had died a painless death.

This leads to the consideration of the probable locality and cause of the explosion, and upon this point it is only fair to state that two totally distinct theories were put forward at the inquest, both strongly supported by evidence, and that after a most carefully conducted inquiry extending over a fortnight the jury were unable to decide in favour of either theory, and so left that part of the matter an open question. The theory brought forward by the workmen's committee, which examined the mine after the explosion, attributed its origin to the firing of a shot in a cross-cut near the face of No. 1 machine-room at C (Fig. 1, Plate XII.). The evidence upon which the workmen's committee based their theory was as follows:—The appearance of the cross-cut indicated that a shot had been fired during the shift, which had just started when the explosion took place. They found coal down, which they could not account for on any other supposition. The body of the shot-firer was blown against the face of the room, and the position of the hose-pipes and one empty car was consistent with an explosion having taken place at the point indicated. Further, the men, who were most experienced and competent miners, swore positively that, when travelling from C across the main deep and along the main return-airway in the direction of the MacDonald level (the airway being marked J on Fig. 1), they found the timbers and brattice blown in the direction of the MacDonald level.

Having heard this evidence, as well as that given in contradiction, the writer is driven to the following conclusion, and it is one which it will be well to discuss, namely:—Either that the original explosion occurred at C, or that there was a local explosion: one or the other being necessary to account for the position of some of the bodies and appliances in the No. 1 machine-room. If, after considering all that remains to be said on this subject, it is thought that a local explosion could be produced at this point, subsidiary to the greater explosion, then the writer thinks that it would be sufficient to account for the conditions presented.

The other theory, put forward by the management and supported by the Government experts, is that at the face of the MacDonald level, at D, where a small feeder of gas was known to exist, and was found still to be giving off gas after the explosion,

the gas was fired and conveyed the explosion to the coal-dust, which was abundant in that part of the mine, and thence it was spread throughout the workings. In support of this latter theory, it must be admitted that there is a strong point in the actual presence of a feeder of gas at the place indicated, but the question of how it was fired will forever remain a mystery. The experts claimed that they were able to trace the direction of the force of the explosion from D outward along the MacDonald level and the working-rooms therein to G: part of the force travelling through the airway, J, to the west, and part through the airway, K, leading to the No. 3 mine. In this connection it must be noted that the chief-superintendent of the company attributed the widespread character of the explosion to the dust, which had accumulated in the old workings, the area of which is stated to be upwards of 100 acres. Matches were found in the pockets of some of the miners, as well as pipes and tobacco, but none were found in the pockets of the men recovered from the MacDonald level.

We have now sufficient information to enable us to weigh to some extent the probabilities connected with this terrible disaster, and to suggest some important considerations. As to the possible cause of the explosion, it should be borne in mind that, although the mine was known to be gaseous, and naked lights had been abolished for some 2 years or more, as a matter of fact the mine had been reported free from gas for many months, and the Government inspector of mines, who made a monthly examination, had failed to discover gas during the present year. Therefore it may be taken for granted that the mine was considered (on all hands) to be free from gas at the date of the explosion. There is the further consideration that no prospective headings were in operation, which could unexpectedly tap a large feeder, and that, so far as is known, and indeed as the writer thinks results prove, there was no accumulation of gas in the old workings. On the other hand, the evidence showed (and on this point there was abundant evidence) that throughout the whole of the mine there was a considerable accumulation of coal-dust. In the main roads, and especially in the main deep (Fig. 1, Plate XII.), it was said to have accumulated to a depth of 18 or 20 inches. In the old workings, it was admitted by all parties that no dust

whatever had been removed since the workings were shut off, and that there was a considerable quantity there. The only attempt to remove dust was at the working-faces, where it was taken out before shots were fired. It is admitted that the system of removing the dust was very imperfect, there being no regular staff of men employed for the purpose, and no rule for constant removal. The evidence seemed to show that it was removed chiefly when it became an impediment to haulage. With the exception of three or four points in the mine, where there were sudden alterations of gradient and the water which was naturally given off by the strata accumulated, the whole of the mine was dry, and in pursuance of the requirements of the Coal-mines Regulation Act it was customary to do some watering in the working-places before firing a shot. This, however, was not systematized, the only appliance being an ordinary wooden tub with a bucket or can, and the evidence distinctly showed that with such appliances the amount of water was quite inadequate. It will be seen from the foregoing facts that, whatever may have been the case with respect to gas, there was a sufficient accumulation of dry coal-dust, throughout the mine, to produce a terrific explosion if it were once started, and the only problem in the whole case is as to how it was started.

The writer is disposed to think that a careful study of the conditions existing, in the light of experiments recently made with coal-dust, might possibly lead to the conclusion that this explosion, like many others, might have originated without the assistance of gas. Experienced miners employed in this mine deposed to the fact that the atmosphere was so loaded with dust that it would accumulate upon the lamp, and that upon shaking the latter to get rid of the dust they have frequently known the lamp to be filled with flame, in a number of places where there was no possibility of gas being present. The question is whether, in such a mixture of coal-dust and air, such a flame might not communicate with the air surrounding the lamp and so precipitate an explosion. Then there is the further condition known to exist of constant blasting, in a mine in which the atmosphere was charged with dry coal-dust. Is it within the knowledge of any of the members that under such conditions an explosion has been produced without the presence of gas? There is abundant evidence, repeated again and again, to show that in the Fernie

mine coal-dust has been frequently set on fire by a blast, and great difficulty has been experienced in extinguishing it. Is it possible that this ignition may have gone to the point of explosion? If either of these latter questions can be answered in the affirmative, it would not be necessary to look any further for the cause of the Fernie explosion; but as the other theory referred to was so firmly held by the Government experts it is only fair to examine it, and in this connection the first qualifying consideration is that the lamp in use must be undoubtedly classed among the defective safetys. It is a simple bonnetted Clanny lamp, and, within a few feet of D where the small feeder of gas existed, one of these lamps was found completely shattered and evidently blown to pieces by the force of the explosion, whether the original one or not it is impossible to say. But certainly an important factor in the case is the presence in the mine of a lamp of this class, which in contact with any feeder of gas would immediately become an instrument of danger and of possible ignition.

The theory that the small feeder of gas, referred to, originated the explosion is not, in the writer's opinion, a very strong one for the following reasons: (1) The quantity of gas given off was so small, that only in the case of almost incredible carelessness could it have accumulated in sufficient quantity to have caused an explosion. (2) It was known to exist a long time before the occurrence of the explosion, but it was so feeble that it could not be detected by a lamp, even when the lamp was held close to it, and one of the men, an experienced miner, who gave evidence, testified that the only way that he could devise was to place his ear close to the feeder when he could feel what he described as a small breath against his face. The Company's chief engineer, who supported this theory, admitted on cross-examination that he did not think the feeder yielded as much as 10 cubic feet per minute, and certainly the evidence tended to show that the quantity would be much less than this. Then there is the further difficulty that, according to the evidence of the chief engineer, there was an air-current of from 400 to 600 feet per minute velocity passing along the MacDonald level and at the very point where this gas-feeder existed, so that nothing could account for the ignition of the gas, so far as the writer is able to see, but an interference with the air-current which would allow the gas to accumulate instead of being carried off. How this could have continued long enough

with so feeble a feeder, to fill even the upper portion of the levels and bring the gas down to the lamps the writer is at a loss to understand, it being remembered that the gas-feeder was in the roof of the seam of coal, which was 6 feet high.

The only way in which the writer thinks that it is possible for this gas to have been ignited, without assuming the grossest possible negligence amounting to criminality, is best illustrated by Fig. 2 (Plate XII.), which shows the arrangements of bratticing at the point in question, the gas-feeder being shown at D. The MacDonald level, 12 feet wide and 6 feet high, was ventilated by means of board-brattice, extending from E to F, the air going in along the upper side and returning along the lower side to the Beaver level. At E, there was a door extending from E to G, through which the cars travelled upon the track to the face of the Beaver level; there was no check of any kind, so that whenever the cars were run into the Beaver level, the door, E G, was open and possibly, as was admitted in the evidence, left open until the return of the driver. Such being the case, there would be an interval when ventilation would be entirely cut-off from the MacDonald level, and during that time the gas given off at the feeder, D, would be accumulating. The whole question is whether the accumulation would be sufficiently rapid to reach the danger-point before the ventilation was renewed by the closing of the door, E G; and in this connection one has to consider whether it is possible or probable that the men working at the face of the MacDonald level would be content to be deprived of air by allowing the door to remain open long enough for any considerable accumulation of gas to take place. Be that as it may, these are, so far as the writer has been able to discover, the only considerations bearing upon this suggestion as to the origin of the explosion.

In the course of the enquiry, many interesting views were brought forward, and as they led to much speculation and theorizing, the writer will mention a few of them. There was a controversy between the Government experts and the miners, resulting in a difference of opinion, as to the direction in which the force of the explosion travelled, and it is significant that two bodies of experienced men travelling over the same ground, noticeably between No. 1 machine-room and C, along the airway, J, and the MacDonald level should resolutely maintain that the

evidences of direction were exactly opposite, the workmen maintaining that the evidence all pointed to the forces having travelled from C towards the MacDonald level and the Government experts maintaining that it travelled in exactly the opposite direction. On this subject of conflicting direction of forces, the writer concluded long ago, and the Fernie explosion has confirmed it, that there is no persistent direction resulting from a great explosion of this kind, but that where (as in this case) the explosion covers the whole of the mine, the force manifests itself according to the weakest point of resistance in every possible direction. Thus, taking the main deep (Fig. 1, Plate XII.), nearly all the air-stoppings on the eastern side of the main deep were blown westward towards the deep, while several of the air-stoppings on the western side of the main deep were blown eastward. In many of the rooms, also, there were evidences of the tools having been blown in different directions in the same room, so that one is driven to the conclusion that wherever the explosion originated, and however it spread through the mine, whether as one continuous blast or in the form of one original blast and a number of local explosions, the evidence of direction of force is both conflicting and erratic.

Another interesting question raised and greatly debated was as to the position in which coal-dust would be found, upon the posts standing perpendicularly in a road or airway along which passed the blast from the explosion. Some of the witnesses maintained that the force of the explosion would drive the dust into the sides of the timber upon the side nearest to the direction from which the blast came, while others maintained that the force of the blast would clean that side of the post and leave the coal-dust adhering upon what may be called the far side. In the writer's experience both are correct, to a certain extent. Given the case of a post upon which there was already a certain accumulation of coal-dust, the writer is convinced that a strong blast would hurl the minute particles of dust on the near side of the post and drive them into it so that they would be discovered by explorers, and at the same time dust might remain upon the far side of the post if it had previously been there. It will be interesting to hear what any of the members, who have had experience in explosions, have to say upon this point, because undoubtedly there are cases in which conclusive evidence as to direction of force may be

extremely important in fixing the location whence the explosion started originally.

The writer finds, however, that by far the most interesting aspect of the question, from the standpoint of the mining-engineer, is that this was essentially a coal-dust explosion. In company with the chief Government engineer, he hurried to the mine within a few hours after the explosion had occurred, and remained there for more than six weeks, being present throughout the Government enquiry, and he had no difficulty in coming to the conclusion that, whatever may have originated the explosion, it was coal-dust which carried it throughout the mine. There was no evidence whatever of the slightest quantity of gas at any point in the mine except the small gas-feeder already referred to, and this was so inconsiderable in quantity that, but for the other prevailing conditions, the effects of the explosion would have been confined to the face of the MacDonald level and the loss of life would probably not have been more than 2 or 3 men. In his experience, extending over thirty years, there has been no explosion so directly attributable in all its disastrous results to the presence of coal-dust, nor one more calculated to arouse the mining-engineer to a sense of responsibility in dealing with what Prof. Galloway has properly called "a more dangerous element in coal-mines than gas." The behaviour of the coal-dust in this case is in itself an interesting matter for study, because it fully bears out the theory which has been laid down for several years as to what actually takes place under such conditions. There may have been a slight explosion of gas, the presence of coal-dust leading to the generation of carbonic oxide; this, distributed by the force of the explosion and coming into contact with floating bodies of dry coal-dust, caused instant distillation, the production of more carbonic oxide, the using up of whatever oxygen could be reached, and in several localities the production of further explosions. Upon this latter point, there can be no doubt, for the reasons stated earlier in this paper. So that it is possible with the mind's eye to see how in a few seconds this explosion, which was slight and local in its initiation, finding a suitable medium upon which to operate, ran throughout the whole of the mine with the speed of the electric fluid, producing universal ignition, concussion and local explosions, of which the

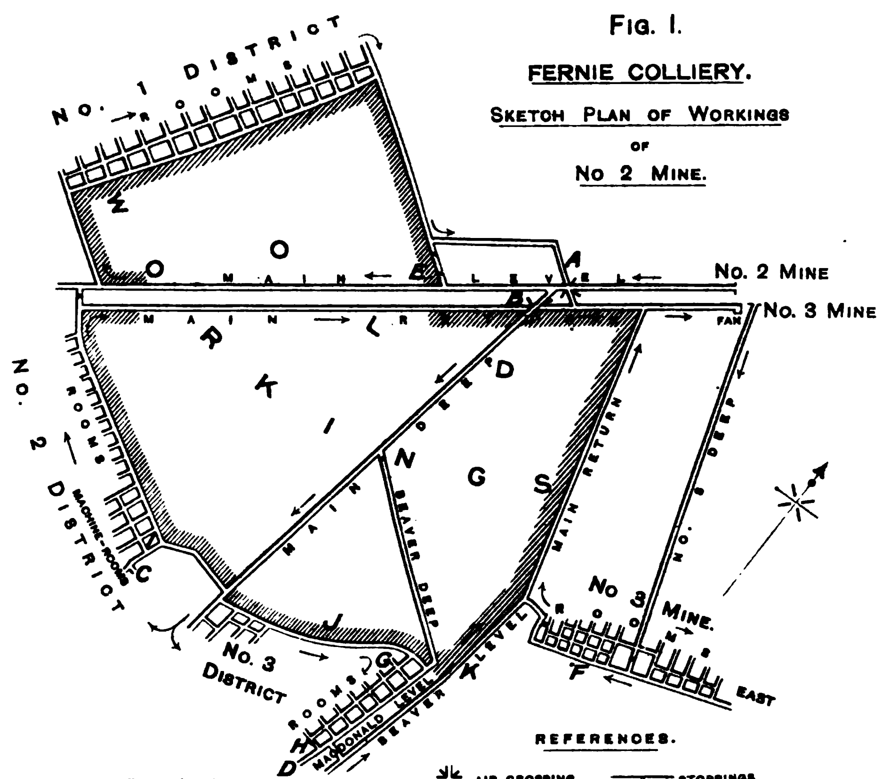
only constant feeder was an accumulation of coal-dust. This theory is fully borne out by the condition of the mine; for instance, in nearly all the working-places, where the coal-dust was freest and purest, there was considerable coking both upon the timbers and the sides of the working-places, whereas there was no coking discovered in the hauling-roads or airways. The writer attributes this to the greater facility with which the purer coal-dust yielded to the influence of the explosive current; it also explains the widespread production of after-damp.

There are some lessons which should be learned from this catastrophe, coming as it does upon the heels of others in which the same prominent features have predominated. The writer thinks that we may well begin to doubt the efficacy of "watering" as a preventive of coal-dust explosions. Not that it could be claimed that the watering adopted at the Fernie mine was in any sense thorough or satisfactory, but because there were considerable areas of the mine where water was lying or dripping, and yet these wet areas had no effect upon the spread of the explosion, which passed over or through them with apparently the same ease as would have been the case if they had been dry. Another deduction is that the evidence adduced at this inquiry with respect to the action of coal-dust upon a safety-lamp should lead to a study of the possible ignition of a mixture of coal-dust and air and the possible production of an explosion through this medium. The third conclusion, and one which has been forced home to the writer's mind more or less during the last ten years, is that blasting should be abolished in dry and dusty mines, apart altogether from the question of gas. In other Canadian mines, under the writer's control, he has known coal-dust to explode in a working-room as the result of a blast, and although there is no direct evidence of this in the Fernie mine, there is, as already stated, repeated evidence of coal-dust being fired. He would suggest further consideration as to the effects of violent concussion in agitating the particles of coal-dust which float in the air, and producing a degree of heat rendering the atmosphere highly inflammable and possibly susceptible to influences which would not be dangerous under other conditions. The writer has used most of the so-called safety-explosives, and has tested all those upon the Permitted List, and whilst he is, of course,

Fig. I.

Fernie Colliery.

Sketch Plan of Workings of No 2 Mine.



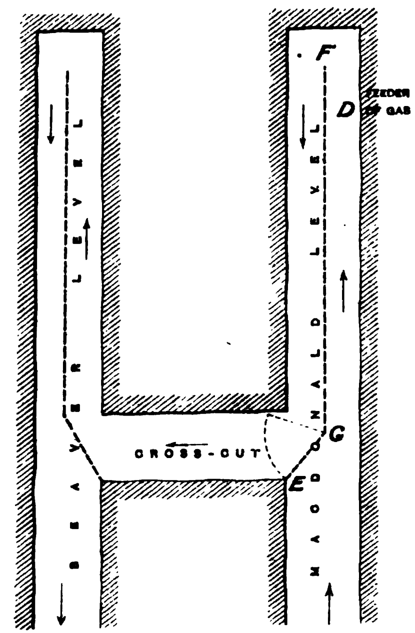
Approximate Scale, 1,000 Feet to 1 Inch.

References.

Air-crossing. Stoppings. Direction of ventilation-current.

Fig. 2.—Fernie Colliery.

Sketch Plan illustrating the mode of Ventilating the Macdonald and Beaver Levels.



Scale, 30 Feet to 1 Inch.

prepared to admit that a higher percentage of safety might be attained by some of these than with ordinary powder, he is convinced that none of them are absolutely as safe, as is popularly supposed; and he would go further and state that none of them are sufficiently safe to meet the reasonable requirements of modern mining. While with the better explosives there is a lessened danger of ignition of gas or coal-dust, there is no mitigation of the dangers arising from concussion (which have been referred to). The writer sincerely hopes that the day has nearly arrived when we shall have learned our lesson in this respect, and when the sacrifice of human life shall have been sufficient to purchase practical immunity from danger by the universal use of safety-lamps and the total abolition of blasting in all dry and dusty mines.

Mr. W. N. Atkinson (H.M. Inspector of Mines, Barlaston) wrote that Mr. Blakemore had no hesitation in attributing the extension of the Fernie explosion, and practically the whole of the damage done, to coal-dust; but he appeared to be in doubt as to whether such an explosion could be initiated without fire-damp, and asked, "Is it within the knowledge of any of the members that under such conditions an explosion has been produced without the presence of gas?"* It is well known that in this country a number of extensive explosions have been attributed by many engineers to the ignition of coal-dust in the complete absence of fire-damp, and the possibility of such explosions has been proved experimentally. It might have been supposed that the occurrence of extensive explosions in old collieries, like Camerton and Timsbury, in Somerset, where fire-damp had never been found, either before or after the explosions, would have set the question at rest; but possibly Mr. Blakemore had not seen accounts of those explosions.

It is not possible, from the brief account of the indications observed at Fernie colliery, to form any opinion as to the probable point of origin of the explosion, but a comparison of the conditions described at the two suggested points of origin leads him (Mr. Atkinson) to the conclusion that the point, C, where

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 455.

the shot was fired, was a more probable point of origin than the point, D, favoured by the experts, at the face of the MacDonald level.

The account of the attempted escape of Brearley and his companions from No. 1 district corresponds closely with what has been observed in other explosions, and illustrates the danger of rushing out from a district not affected by an explosion into roads traversed by it. If these men had remained in No. 1 district, and had done their best to prevent the after-damp from invading it, it is possible (if not probable) that they might have lived until the road out was sufficiently ventilated for them to be able to escape by it.

The escape of the men from the east side of No. 3 mine is, on the other hand, difficult to understand from the account and the plan. It would appear impossible for these men to travel up No. 3 deep directly after the explosion if that road had been traversed by the blast, as might be inferred by the fact that hot dust was found near the entrance. Possibly there are connections, not shown on the plan, between No. 3 deep and No. 2 mine, which might account for the presence of hot dust near the top of No. 3 deep, without that road having been traversed by the blast throughout. Or it may have been that hot or burning dust ejected from No. 2 mine had been drawn into No. 3 mine. Otherwise there must be some unrecorded circumstances to account for the escape of the men from the east side of No. 3 mine. The evidence in support of the statement "that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the first explosion,"* is not given in sufficient detail to carry conviction on the point. The fact that, at three places, the bodies of men were terribly mutilated, while men in intervening working-places had not been subject to force, might be capable of explanation in another way altogether, if the exact details of their positions at the time of the explosion and the configuration of the localities were fully known.

With reference to the theoretical statement concerning "the behaviour of the coal-dust," which it is said "fully bears out the theory which has been laid down for several years as to what actually takes places,"† it may be asked on what investigation of

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 452. † *Ibid.*, page 459.

the chemical re-actions occurring in a coal-dust explosion such theories are based.

Mr. Donald M. D. Stuart (Bristol) wrote that the subject of colliery-explosions had been carried to a more definite issue than appeared in this interesting paper upon the Fernie mine-explosion. The inception of the explosion was left in uncertainty between the opposing views of gas and coal-dust, and this could scarcely cause surprise when the conditions of the mine were taken into account. Mr. Blakemore stated that "the mine, being practically free from water, was dry and dusty, and a considerable amount of gas was produced and could generally be detected;"* and also "throughout the whole mine there was a considerable accumulation of coal-dust."†

In such circumstances, there was presumably reasonable ground for difference of opinion; but explosions had occurred in mines at home in which the two elements of gas and coal-dust did not co-exist, consequently there was no complication in determining which of the two agents was responsible for their inception. The explosions at the Camerton collieries in 1893, and at the Timsbury collieries in 1895, were evidence to the point. The two collieries were free from gas, in fact gas had never been found in the seams in which the explosions occurred, although they were worked in numerous other collieries in the district and were now approaching exhaustion. The seams had been worked with naked lights during their entire history, reaching back to the early years of the nineteenth century, and naked lights were used in them to this day. The only explosive agent in the mines was coal-dust, and the explosions were traced home to this agent. The potentiality of bituminous coal-dust to originate a mine-explosion was, therefore, a fact of experience, although the complexities in the Fernie mine disallowed such a definite conclusion. This fact in regard to coal-dust, however, did not warrant an alarmist feeling, nor did the experience in mines in Great Britain support the opinion that coal-dust was "a more dangerous element in coal-mines than gas."‡ The official records showed that explosions originated by ignition of coal-dust were an almost inappreciable fraction, compared with the explosions by ignition of gas.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 451. † *Ibid.*, page 454.

‡ *Ibid.*, page 459.

The circumstances in the Fernie mine were suggestive as to the origin of the explosion. Gas was given off, safety-lamps were used, and matches, pipes and tobacco were found in the pockets of some of the men.* And with facts of this nature, it was not difficult to account for the original ignition. Mr. Blakemore seemed to support the supposition that a shot had been fired, and that the explosion was initiated by coal-dust, near a place where the bodies of some of the men were found terribly mutilated.† This mutilation Mr. Blakemore considered could only be accounted for by explosive violence. The observations made in explosions that had been traced home to shots igniting coal-dust, were that no violence was developed at the point of origin. The first exhibitions of violence in the Camerton and Timsbury collieries were distant 408 to 573 feet from the fatal shots. This condition was observed in the explosions that preceded as well as those that have occurred subsequently, and had been traced home to a similar cause. The origin of the explosion in the exhibition of violence at the place where the supposed shot was fired, was opposed by the observations at the point of origin of explosions at home. Mr. Blakemore evidently recognized the difficulty and offered an alternative explanation of the violent effects. He said "either that the original explosion occurred at C, or that there was a local explosion: one or the other being necessary to account for the position of some of the bodies and appliances."‡

The alternative of a local explosion led to what in his (Mr. Stuart's) opinion was the important point in the paper, the phenomena of propagation. Mr. Blakemore said that "the evidence showed that, with few exceptions, the men were killed by after-damp, the exceptions being somewhat peculiar, and clearly illustrating the fact that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the main explosion."§ The observation of facts contained the secret of propagation, and was capable of explaining all the phenomena of the explosion that the paper recorded. A distinctive phenomenon in the explosions at the Camerton and Timsbury collieries was, local explosions at intervals along the paths of coal-dust, limited in extent and

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 454.

† *Ibid.*, page 452. ‡ *Ibid.*, page 453. § *Ibid.*, page 452.

terrible in force. These exhibitions of explosive violence were measured, with the distances between them, at the time; the facts were also recorded in the *Transactions*.* This theory of local explosions did not fit the idea of a continuous and instantaneous blast through the mine, which was in his (Mr. Stuart's) opinion the standing obstacle to the provision of effective means for the prevention of propagation of explosions and wreck of the workings. The idea utterly failed to explain the phenomena observed in the paths of the explosion, and it was matter for surprise and regret that the resultants of explosive forces which directly opposed the idea, were still pronounced "conflicting and erratic," while they were the handwriting of nature's laws revealing the causation of the explosion. He (Mr. Stuart) had noted other interesting phenomena in the paper, but considered that the theory of local explosions was the only key to their solution; and as propagated explosions were still occurring, causing calamitous loss of life and destruction of property, he (Mr. Stuart) thought that the Institution might, in accordance with its inception and history, undertake an investigation of this point, and, when another explosion occurred, depute two or three members to make exact records of the conditions left in the path of the explosion; and thus establish a foundation of fact for the understanding of propagated explosions, and consequently for their prevention.

Dr. J. S. Haldane (Oxford) wrote that he had read Mr. Blakemore's paper with interest, but as to the debatable points raised in it, he should not care to add any criticisms without more precise information concerning the facts observed. He confessed that he did not understand either Mr. Blakemore's theory of the propagation of dust-explosions, or the exact grounds of his objection to safety-explosives and doubts as to the efficacy of watering and trustworthiness of safety-lamps in presence of dust.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that Mr. Blakemore states that the main air-crossings and nearly all the air-stoppings alongside the main deep and the main level were blown out, but he does not state in which direction the force had passed: from the intake airway, and presumably haulage-road to the return airway or *vice versa*. There

* *Trans. Inst. M.E.*, 1896, vol. xii., page 371.

would probably be no difficulty in determining this, a most important indication.

With the exception of a party of 22 men, who had left their working-places and were found with their lamps in their hands suffocated by after-damp, all the other victims of the explosion were found dead in their working-places. Mr. Blakemore does not state, with reference to this party of 22 men, whether evidences of the explosion having reached their working-places were observed, or if they were burned; it is probable that both these questions could be answered in the negative, and if so the reason why the explosion had not reached them should have been discussed. Was there any absence of coal-dust to account for it, or was there any other reason?

The fact that the majority of the victims of the explosion, probably all who were in the actual field of flame, were found dead at their working-places is of great importance in determining the agent that led to the extension of the explosion. It appears, to him (Mr. Atkinson), impossible to suppose that the atmosphere of any considerable area of workings could become explosive owing to the presence of fire-damp, without the miners having observed gas firing in their lamps, and showing by their movements before the explosion evidences of alarm. If the inflammable agent is coal-dust, the reverse is true; the mine in its normal condition contains the elements of explosion; an air-wave, to raise the dust, and flame is all that is necessary to initiate a wide-spreading explosion. Where, as has several times happened, the miners are working with naked lights, at the first of which a sudden issue of fire-damp would ignite, the fact of there being no movement before the explosion is still stronger evidence that fire-damp could not be the inflammable agent. This matter was fully discussed in *Explosions in Coal-mines* by Mr. W. N. Atkinson and the writer, and was referred to by him in his evidence before the Coal-dust Commission.

With regard to the position in which coal-dust (whether coked or not) is found upon props standing perpendicularly in a road along which the explosion has passed, the experience of the writer in a large number of cases is that it is usually deposited or found in a direction opposite to that in which the explosion has travelled. In many of these instances, no doubt existed as to the direction in which the explosion had travelled, as when it had passed into

districts where no person was working at the moment of the explosion.

Sufficient data are not given to make it worth while discussing the point of origin of the explosion, but it may be stated that if coal-dust exists on the sides, roof and timbers, as well as on the floor, of an intake airway, there can be no reasonable doubt that a shot may in such a situation initiate a wide-spreading explosion in the entire absence of fire-damp. Such a result, however, is not so likely at the working-face, where the dust is coarse, and here the entire absence of fire-damp can rarely be asserted.

The feeder of gas referred to by Mr. Blakemore, amounting to 10 cubic feet per minute or 600 feet per hour, could easily accumulate, if not dissipated by ventilation, and form an explosive mixture quite sufficient to initiate an extensive explosion in a dusty mine.

The references to local explosions do not seem based on any satisfactory evidence; it seems more probable that there was only one explosion, varying no doubt at different points as regards the force developed.

It is stated that "in nearly all the working-places, where the coal-dust was freest and purest, there was considerable coking both upon the timbers and the sides of the working-places, whereas there was no coking discovered in the hauling-roads or airways. The writer (Mr. Blakemore) attributes this to the greater facility with which the purer coal-dust yielded to the influence of the explosive current."* There are probably errors in this statement, because:—(1) The freest and purest coal-dust exists on haulage-roads, particularly on their upper surfaces. (2) Greatest force is always developed on haulage-roads, where such fine dust exists. And (3) coal-dust exposed to rapid currents of air, on haulage-roads, seems to absorb oxygen from the air and loses its property of coking, and this may be the reason why coked dust is rarely observed in such situations.

The statement that wet areas had no effect upon the spread of the explosion should be supplemented, if possible, by details.

The remarks about shot-firing may be questioned. If all the dangers attending shot-firing in mines are thoroughly understood and guarded against, there seems to be no reason why shots should not be fired with safety.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460.

Mr. H. Hall (I.S.O., H.M. Inspector of Mines, Rainhill) wrote that Mr. Blakemore's account of the effects of the explosion at the Fernie colliery brought vividly back to his mind several of the great British explosions: the phenomena in each case being so similar that one description does for all. The members are not told, in so many words, what kind of explosive was in use at Fernie, but reading between the lines* it may be assumed that it was gunpowder, and if this guess be correct, then the solution of the problem becomes at once less difficult. The introduction of safety-lamps, in place of open lights, two years ago, without at the same time rigorously excluding such a dangerous explosive as gunpowder, would in his (Mr. Hall's) opinion make an explosion of this character more likely to happen; because the lamps would render accumulations of gas possible, less dreaded, and hence also less guarded against. It is stated that "a considerable amount of gas was produced and could generally be detected."† Now, once accumulations of gas come to be disregarded, and blasting with gunpowder is continued (there was "constant blasting" in the mine‡), it is not surprising if, sooner or later, a flash from a shot reaches one of these accumulations; and such an occurrence in a mine of the character of Fernie (well ventilated and of a specially dry and dusty nature) would almost inevitably give rise to a wide-spreading and devastating explosion.

The phenomenon of coal-dust flaming inside the safety-lamp is a very familar one, but he (Mr. Hall) was not aware that this had ever caused an ignition outside the gauze.

He (Mr Hall) agreed with Mr. Blakemore that it is often most difficult to arrive at anything definite from the signs of passage of flame and force, as they are usually very contradictory in an extensive explosion, and more especially so if coal-dust is the chief agent. In the latter case, the explosion requires somewhat large quantities of air to maintain it, and its violence is probably renewed again and again on meeting with fresh supplies of air from the several airways. Deposits of coke might be found, he thought, on either side of props, as the settlement seems to take place after the blast has passed and when the air is quietly fluttering to rest.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460.

† *Ibid.*, page 451. ‡ *Ibid.*, page 455.

It is interesting to note that in the Fernie explosion, as in many others, nearly all the victims were found in or very near their several working-places. Mr. Blakemore states that "with the exceptions noted hereafter, all the bodies were found in the places where the men were known to be at work, death in every instance having been instantaneous."* Then again, "all the other men, who were killed, were found at or near to their working-places, and most of them had not moved."† Could Dr. J. S. Haldane (who recently reported that nearly all the deaths in colliery-explosions were due to carbon-monoxide poisoning) tell the members whether death from this cause is consistent with (1) the fact of apparent instantaneous death, and (2) with the apparent absolute necessity that this gas would take some time to reach the men working at the far-ends, away from the site of the explosion? During this interval one would naturally expect the men to make an effort to escape. The first instinct of men in a position of this kind is to get together as quickly as possible, and the bunches of men found together have no doubt been poisoned: but the deaths of those found with their picks in their hands, as it were, seem to demand some further enquiry.

Mr. JAMES ASHWORTH (Derby) wrote that the originating cause of the Fernie explosion, as in many other cases, had been left shrouded in mystery, and Mr. Blakemore suggested three possible causes, namely:—(1) The failure of a bonnetted Clanny safety-lamp; (2) a shot fired in one of the working-places, or (3) gas ignited by some undiscovered cause. Whatever may have been the original source of flame, all the witnesses, at the enquiry, were agreed that the extent of the explosion was due to the presence of coal-dust. Coal-dust is recognized by many mining-engineers as a far more dangerous element of risk, in a colliery, than fire-damp. It has been observed on the American continent that the greatest number of explosions have taken place in bituminous-mines, and that anthracite-mines, which have often from 3 to 4 per cent. of fire-damp passing up the upcast shafts, are not so liable to explosions. Mr. W. D. L. Hardie, of Lethbridge, has stated that all the superior coking-coals produce a dust which has a more or less "greasy" feel, indicating that some of the heavy hydrocarbons of the paraffin series are present in the volatile matter; and that if such coal-seams give off fire-damp, it is very

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 451. † *Ibid.*, page 452.

likely to be "sharp," indicating that hydrogen, as well as heavy hydrocarbon gases is a possible constituent of the fire-damp. Under these conditions, which, from Mr. Hardie's personal observation, hold good at Fernie, the inflammable point of the explosive gas given off is very much lower than that of ordinary fire-damp: and it can therefore be readily imagined how easily the dust may be raised to an incandescent heat, and the hydrocarbons distilled in quantities large enough to cause an explosion of any magnitude.

Mr. Blakemore, Mr. Hardie and others are in accord with him (Mr. Ashworth), in concluding that coal-dust in the meshes of a safety-lamp may become incandescent almost instantly, and thus pass the flame to the mixture outside the lamp.* The safety-lamp, in use at Fernie, was of the bonnetted Clanny type, probably of the same pattern and make as that used in the fiery mines of this country, and although the cause of the ignition of fire-damp and dust was undetermined, yet we find that Mr. Blakemore formed a strong opinion that the initial cause was the failure of a sound lamp to prevent the flame, of ignited coal-dust and fire-damp within the lamp, from passing through the gauze, and thereby exploding the surrounding atmosphere. The jury also endorsed this opinion by their verdict, namely, "that the safest explosives and most approved safety-lamps be used; and that a more thorough inspection be adopted at these mines, throughout the old workings and rooms contiguous to the air-channel that are not being worked." The jury also found that the initial cause was augmented and intensified by coal-dust. It would appear that the directors of the company also agreed with this view of the cause, because they took out all the bonnetted Clanny lamps and replaced them with Wolf lamps burning benzolene as the illuminant. As to whether the mine is more safely lighted now than it was before the change of lamps, is a subject which might very properly be debated, on the basis of the accidents which have occurred in this country.† The serious point to be considered by engineers is, that there are probably hundreds of thousands of the same type of safety-lamp in daily use in the most dangerous and fiery mines of this country. Many authenticated cases of the failure of bonnetted Clanny lamps, when used under ordinary conditions, are known; and we may, with

* "Improved Safety-lamps of the Davy and Mueseler Types," by Mr. James Ashworth, *Trans. N.E. Inst.*, 1880, vol. xxix., page 145.

† "Failures of Safety-lamps whilst in Use, and some of the Disasters caused thereby," by Mr. James Ashworth, *Transactions of the Manchester Geological Society*, 1900, vol. xxvi., page 519.

advantage, closely and dispassionately take the lessons into more serious consideration than they have heretofore received. Some of the best-known failures of bonnetted Clanny lamps in this country occurred at Allerton Main in 1894, Shakerley in 1895, Universal colliery in 1901, and Abertysswg (Tredegar) in 1902. In all these cases, the only source of flame was a safety-lamp of the bonnetted Clanny type, and the lamps were all exposed to mixtures of coal-dust, fire-damp and air, but in no case were the lamps on examination and experimental testing found to be deficient. None of the lamps were, however, submitted to experiments in which coal-dust formed a factor. The importance of submitting safety-lamps to tests in which coal-dust is a factor will be more readily realized when it is remembered that the particles of coal-dust floating in the air-current are so small that they will easily pass through a standard mesh, and if brought into a state of incandescence within the lamp will pass outward in a stream of fire. The ignition-point of such fine coal-dust is lower than that of fire-damp, and therefore mixtures of fire-damp and coal-dust become more dangerous than fire-damp by itself.*

Other influences which may have affected the initiation and extent of this explosion were:—(1) It occurred whilst the second shift of coal-getters, which commenced at 3 o'clock, was at work; (2) the district in which the explosion occurred was described as the dirtiest and dustiest of any of the mines at Fernie; (3) the barometer would probably stand at from 25 to 26 inches only (due to the height of the mine above sea-level); (4) blasting with powder was allowed; (5) local explosions of coal-dust had often been caused by shots; (6) electricity was extensively used for hauling and pumping, and live and bare wires were carried along the haulage-plane at 250 volts; (7) the electric locomotives, which hauled the trams out of the mine, ran for some considerable distance in the return-air, and electric Tripley pumps were also placed in the return-air; and (8) the roads were watered, and in some places naturally wet.

It would be recognized, therefore, that, in addition to the possible failure of a bonnetted Clanny lamp, electricity was a dangerous source of ignition, if, as from the suggested neglect in shutting a door, the air became charged with fire-damp and then came into contact with the sparks from a motor, or sparks between

* "Improved Safety-lamps of the Davy and Mueseler Types," by Mr. James Ashworth, *Trans. N.E. Inst.*, 1880, vol. xxix., page 145.

the connecting arm of the locomotive and the live wire placed close to the roof of the haulage-road, or if a short circuit were possibly formed by a dense cloud of dust constituting a bridge between a bare wire and the rails, floor or roof.

The writer would like to hear from Mr. Blakemore what sort of stoppings were placed between the old gob and the working-faces, and on either side of the main haulage-road, all of which are stated to have been blown out. From the description, it would appear possible for a large fall of roof in the goaf or back workings to have forced out gas at a high velocity into the ventilating current, and thus have been a main cause of the explosion, no matter how the gas became ignited.

One very interesting feature, of which he (Mr. Ashworth) had observed strong evidence in very many explosions in this country, was the instantaneous effect of an explosion on all parts of the mine, often setting up so sudden a percussion of the atmosphere that effects had been produced similar to those which Mr. Blakemore described as universal ignition, concussion and local explosions. At Fernie mine, the evidence of Burrows, who escaped from the No. 3 mine, is confirmatory: he heard no noise, all the candles went out, he felt a pressure as if his head would burst, and afterwards within 50 or 60 feet of the entrance of the mine he put out his hand to save himself from falling, and found that the dust was so hot that he thought his hand was burnt.* The point where this dust was so hot was 3,000 feet from the supposed point of origin, and where there was a considerable quantity of water. This is another proof that wet roads will not isolate an explosion in one district of a mine from communicating the effects to another district, without the flame of the originating explosion actually passing over the intervening space. The instantaneous nature of the explosion is also evidenced by the fact that the men were killed without moving from their working-places, by concussion of the brain, and burned by the sudden percussion of the air. The earliest recognition of the effect of percussion on parts of a colliery remote from the place of origin, will be found in Mr. Joseph Dickinson's report on the Udston explosion, and this effect was also in very distinct evidence in the explosions at Llanerch, Tylorstown, Albion and Universal collieries.

Depositions of coal-dust on props and other surfaces, as an indication of the direction in which the flame of an explosion first

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 462.

passed along a roadway, is also a very interesting subject: and although very contrary indications are often discovered, it appears probable from Mr. W. N. Atkinson's report on the Talk-o'-th'-Hill explosion, 1901, that the face of a prop on which a pyramidal streak of dust is found may be assumed to be the side which faced the blast, and that the more diffused deposit on the opposite side is outbye from the point of origin; but charred dust is nearly always found on the side of the prop that was not facing the blast.

Mr. Blakemore supports his (Mr. Ashworth's) old contention that watering is at the best only a sanitary precaution in a fiery and dusty mine, and that it cannot and never has limited an explosion to one district, because it has no power to reduce the percussive effect of an explosion. He (Mr. Ashworth) also believes that the immunity of the No. 2 mine at Fernie, from previous disaster through shot-firing, has been due to the very cold and dry nature of the air-current, which, at the high altitude of 3,000 feet above sea-level, is its natural condition. The futility of depending on water as a safeguard is easily realized, by noting that 5 per cent. of water-vapour is required to be present to obtain the maximum effect from an explosion, and yet it is not possible to put more than about 3½ per cent. into any mine-current. Watering, therefore, adds to the explosive effect, instead of decreasing it. This fact was distinctly demonstrated in the case of the explosion at the Universal colliery, where the air-current from the York district was practically saturated with moisture, and yet the whole of the latter district was traversed by flame.

Mr. H. W. G. Halbaum (Gateshead) wrote that he had read Mr. Blakemore's paper with great interest, and had no hesitation in stating that the Fernie explosion was a typical example of what was usually called a "coal-dust explosion." He was also of opinion that it was brought about without the initial assistance of "gas" in the mine-atmosphere, at any period immediately though appreciably previous to the catastrophe. He thought that the theory of such explosions would have a wider and more beneficent practical result if the theory were more easily appreciated, and rendered capable of more rapid propagation. And he believed that one important step in that direction would be made if the nomenclature of the theory were overhauled and revised to some extent. They continually spoke of a "coal-dust explosion." Many of them knew exactly what was meant by that term; they knew that

it stood for a certain series of phenomena, and they also knew that the term entirely failed to describe such phenomena—they knew, in fact, that it was a misnomer. They also spoke of such an explosion occurring in the absence of gas. An experienced miner might interpret that expression in the light of his mining idiom, and possibly unearth the true idea underlying the phrase: but a person ignorant of mining idiom, however highly educated otherwise, could hardly be expected to extract any grain of truth from so entirely false a representation of the real phenomena. As a matter of common knowledge, they had the typical explosion of gas, and they had the typical explosion of coal-dust; but, strange to say, it was a matter of scientific fact that the typical coal-dust explosion was, in general, a greater explosion of gas than the typical gas-explosion. Similar anomalies often appeared in the nomenclature of comparatively new theories. The earlier investigators named the phenomena which they imagined to occur; the later enquirers retained the names for the phenomena actually found taking place, with the result that a greater or lesser crop of misnomers survived in the final nomenclature of the theme. In some cases, the retention of those misnomers did no great harm: in other cases, they became appreciable obstacles to progress, and he (Mr. Halbaum) thought that the misnomers in the nomenclature of the coal-dust theory distinctly belonged to the latter class of cases; wherefore, in his opinion, it was essential to replace them by names that more truly described the entities which they were supposed to represent.

He thought that there would be little or no difference of opinion as to which class of explosions the Fernie explosion belonged, and he would therefore confine himself to the discussion of some of Mr. Blakemore's conclusions and suggestions. Mr. Blakemore cast doubt upon the efficacy of watering as a preventive of coal-dust explosions. The Fernie explosion, however, could scarcely be said to justify that doubt, for Mr. Blakemore stated that the watering adopted in the Fernie mine could not be claimed as thorough or satisfactory in any sense. A chain was no stronger than its weakest link, and evidently that link at the Fernie mine was very weak indeed. The explosion was evidently initiated by the gunpowder shot fired in the cross-cut near the face of No. 1 machine-room. If it could be shown that the watering in the vicinity of that shot had been thoroughly and systematically done, Mr. Blakemore's position would have received some support, but all the evid-

ence seemed to point the other way. The fact that the explosion, once started, passed over considerable wet areas in other parts of the mine, proved nothing more than what might easily have been foreseen. The inflammable constituents of the coal-dust, the heat generated by previous explosions, the accessibility of fresh oxygen, etc., on the one hand, and the extinguishing power of the wet areas on the other hand, were, after all, merely the components of the resultant force which enabled the blast to traverse those areas without extinction. The stronger force would, of course, be more nearly reproduced in the resultant than would the weaker. According to Mr. Blakemore's account, the coal-dust was in extraordinary abundance: the ventilation also appeared to have been ample; the combustion must therefore have been maintained with extraordinary severity, and it was little wonder that such a force should successfully pass right through watered areas that might easily have interrupted and quenched a less violent blast. At the Fernie mine, the great mistake lay in not thoroughly watering the ground in the immediate vicinity of the shot. At that initial stage, the destructive power might have been conquered and rendered innocuous in its infancy by simple means, which, however, would be totally inadequate to cope with the accumulated energy of the destructive power at the later stages of its passage through the mine. In his opinion, it would be soon enough to condemn the system of watering after they had given it a fair trial. At the Fernie mine, it had not received a fair trial, and the system adopted was, according to Mr. Blakemore's account, neither thorough nor satisfactory.

Mr. Blakemore's second suggestion, with respect to the action of coal-dust upon a safety-lamp, might be met by the reply that in the event of any explosion within a safety-lamp, the force of the explosion would be limited by the quantity of oxygen within the lamp as well as by the quantity of explosive substance therein, and it would also be limited by the degree of combustion attained. In the case of coal-dust exploding within a lamp, his (Mr. Halbaum's) opinion was that the combustion would be less complete, and the explosive force therefore less powerful, than if a pure and perfect gas had been exploded; and, therefore, in his opinion, the margin of safety obtained by any lamp in the presence of coal-dust was, if anything, greater than the margin of safety obtained by the same lamp in the presence of gas. The principles which governed (and generally also prevented) the passing of flame from the interior of

the lamp to the external atmosphere were, of course, the same in both cases. He was, therefore, inclined to think that the Fernie explosion raised no special question with regard to safety-lamps, such as Mr. Blakemore had suggested.

He was also afraid that he could not agree with Mr. Blakemore's third conclusion, to the effect that blasting should be abolished in dry and dusty mines, apart altogether from the question of gas. His idea of the necessities of the case, however, practically came to the same thing as Mr. Blakemore's idea. His (Mr. Halbaum's) idea was that, not the blasting, but the dry and dusty mine should be abolished. Let the dust be removed, and let the dryness be destroyed by proper watering in the vicinity of all shots. If this were done in any mine, they could continue blasting, but the blasting would never take place in a dry and dusty locality. In many mines it would pay them infinitely better to destroy the dryness and the dustiness of the blasting-sites rather than to abolish the blasting itself. He fully believed that blasting could be safeguarded with success. In addition to the means that he had mentioned, a competent person should be appointed as shot-firer and blasting superintendent. That competent person should not be merely any person who could detect gas; he should understand blasting operations; he should be empowered to condemn any drill-hole not to his liking; and he should also determine the amount of the charge. Any person unable successfully to undertake such duties was unfit to be a shot-firer, and any manager appointing such persons as shot-firers incurred serious responsibility. With the appointment of competent shot-firers, the removal of coal-dust, and the thorough watering of the ground in the vicinity of the shots, he was strongly of opinion that blasting in all mines might be made as safe as blasting in open-air quarries. He granted that a coal-dust explosion, once initiated, and gathering strength *en route*, was a very difficult matter to stop; but he submitted that the prevention of the initial explosion was a very easy matter—at all events, he had yet to hear of the explosion that had occurred where all of the precautions which he had mentioned were faithfully observed.

He agreed with Mr. Blakemore in thinking that the effects of violent concussion in agitating particles of coal-dust might be very serious indeed, although Mr. Blakemore and himself viewed the matter from somewhat different standpoints. He (Mr. Halbaum) did not think that those aerial concussions which Mr. Blakemore

had in view could, taken alone, have any appreciable influence in heating the dust to any dangerous degree. The real danger of a cloud of dust, as opposed to a mere heap of dust, lay in the immense area of exudation thereby offered to the gases occluded in the dust. A simple calculation would show that 5 cwts. of coal, pulverized to cubes having an edge of 0·01 inch, and suspended as a cloud in the air, exposed an area of exudation equal to a longwall-face 3 feet high and 3 miles in length. When they remembered that the same weight of anthracite-coal, raised to the temperature of boiling water only, would expel 50 cubic feet of its occluded gases, the possibilities of the case at once assumed alarming proportions. Let them imagine a blown-out shot to raise that quantity of dust as a cloud in the atmosphere—a very possible case where, as in the Fernie mine, the coal-dust was only removed when it became an impediment to haulage. In such a case, they had at once an immense area of exudation, a temperature more than sufficient to produce a sudden evaporation of the occluded gases, and possibly a temperature or a residue of heat, sufficient to ignite the gases thus suddenly liberated. Whether the last-named effect was produced would depend on the quantity of the charge blown out, and upon the amount of work done by the charge before being blown out. For these phenomena, like all other physical phenomena, were amenable to the principle of work; and that being so, they would see the necessity of having competent shot-firers, men of practical experience and ability, able to so order the placing of shot-holes and charges as to ensure, so far as human skill could ensure anything, that the energy of the charge should be expended in the shot-hole and not outside of it. But even in the contingency of a shot being blown out, the removal of the coal-dust from the vicinity, and the thorough watering of the ground in the vicinity of the shot, should save the situation. The distant coal-dust might be agitated by the aerial concussion, but the matter would end there—the heating effects, so far as the dust was concerned, would, in all probability, be practically, if not absolutely, *nil*.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Blakemore for his interesting paper.

Mr. P. KIRKUP seconded the resolution, which was cordially approved.

Mr. P. KIRKUP read the following paper on an "Improved Railway-rail Fastener":—

IMPROVED RAILWAY-RAIL FASTENER.

By PHILIP KIRKUP.

The very large and increasing railway-traffic of the present day makes the subject of any improvement in the method of securing the rails to the chairs and sleepers of the permanent way of the utmost importance to all concerned. From both an economic and humane standpoint, an appliance giving greater security and safety should be gratefully received by the owners of rolling-stock and the travelling-public generally.

It will be generally known that the ordinary double-headed rail and also the bull-head rail, which are now more generally used by the various railway-companies in this country, are each secured to the chairs by means of an oaken key driven longitudinally between the rail and the outer jaw of the chair. This method of fastening these sections of rail is almost universally adopted, and it will be admitted by engineers and inspectors that its most serious drawback is the liability of the key to become loose and to slip out, owing to the constant vibration caused by the passing of trains over it. Large numbers of men are continually employed on public railways in examining the permanent way and re-adjusting such keys as have become displaced during the interval between each inspection. Another serious source of danger and anxiety is the shaking loose of the keys and fastenings at points and crossings where greater lateral strains arise and liability to derailment is imminent. The danger is more to be feared in summer, owing to the pining of the wooden keys, and consequently greater vigilance has to be observed in keeping them in position so as to secure the maximum of safety.

The cost of maintenance of the fastenings on private railways through workmen and others picking up the displaced keys and taking them home for firewood is an item of some moment. From actual experience, the writer can state that renewals from

this cause are frequent and expensive, more especially where the colliery-owner has a long length of railway to maintain between the pits and the shipping-staithes.

After a considerable number of experiments, the writer has been enabled to arrive at a practical solution of the difficulties enumerated above, and has now pleasure in bringing forward for consideration an entirely new method of fastening the rails to the chairs. This consists of the substitution of a cast-iron or steel wedge and a small hard wooden cushion, for the ordinary key. The wedge has a double flange on each vertical edge, so that when driven downward between the outer jaw of the chair and the wooden cushion, the rail is held secure. The cushion is made of oak, and of a size sufficient only to be embraced by the

FIG. 1.—THE IMPROVED IRON WEDGE APPLIED TO STRAIGHT RAILS.

inner flanges of the iron wedge, and thus it is retained in position to act as a buffer and to meet the unequal expansion and contraction between the steel rail and the cast-iron chair. The outer flanges of the wedge also embrace the jaw of the chair.

The arrangement can be applied to existing chairs, and has the further recommendation of being inexpensive in primary cost and maintenance. The wedges, when driven down with a light hammer, completely secure the rails to the chairs, and, being fixed vertically, cannot shake out of position so as to render the rails at any time insecure and unsafe.

The writer may mention that the engineers of the North-eastern Railway Company have, during the last few months, severely tested the new fastener on lines near the railway-stations at Newcastle and York; more recently a section of the Team

Valley main line has been laid with it, and so far they express themselves as being thoroughly satisfied with the utility of the invention.

FIG. 2.—THE IMPROVED IRON WEDGE APPLIED TO CROSSINGS.

Figs. 1 and 2 illustrate the application of the iron wedge and wooden cushion.

MR. A. L. STEAVENSON (Durham) remarked that several methods had been tried for improving railway-chairs and fasteners, and a successful method had been recently adopted in Cleveland; the invention of Mr. W. Walker, who had adapted to the railway-chair the principle of the safety over-winding hook. Wood was apt to pine and fall out, and it might be pulled out by any persons mischievously inclined, but with Mr. Walker's clutch no wood was required, the rail had a longer life, because it was held in such a position that it met the pressure of the wheel, and instead of the rail wearing down on one side it wore in the centre. It was no heavier than an ordinary chair, and any vibration only tended to hold the rail faster, and chocks could only be removed by removing the rail.

Mr. Charles A. Harrison (North-Eastern Railway, Newcastle-upon-Tyne) wrote that he considered Mr. Kirkup's rail-fastener was a very good one, but he could not agree with his conclusion that it would save any labour, because whatever rail-fastener or key was adopted the men would still have to inspect their lengths of railway twice a day, and other considerations would forbid the increase in the length of line of which each gang of three men are supposed to be in charge.

Mr. Kirkup pointed out that his paper merely described a fastener adapted to the existing railway-chair, and was not a new form of chair, as in the case of the Walker clutch. As regards the adoption of steel throughout, in preference to cast-iron and wood, it was considered that greater security was obtained by using a soft material like wood which would allow of greater freedom of expansion between the steel rail and the cast-iron chair.

Mr. J. K. Guthrie (Preston) asked whether vibration caused the iron wedge to creep upward.

Mr. Kirkup said that, in practice, the surface of an ordinary casting was sufficiently rough to grip the timber, even without the tooth, which, however, was provided. After a practical test of the cast-iron wedge at the Central Railway Station, Newcastle-upon-Tyne, where many hundreds of trains were passing over the rails every day, the engineer to the North-Eastern Railway Company had quite recently laid down ½ mile of track with the new fastener on the main line to London, and it was standing the test most admirably.

The Chairman (Mr. J. S. Dixon) proposed a vote of thanks to Mr. Kirkup for his paper.

Mr. M. Walton Brown seconded the resolution, which was cordially approved.

Mr. W. C. Blackett read the following paper on "Underground Stables":—

UNDERGROUND STABLES.

By W. C. BLACKETT.

Much interest was shewn by members in their discussion upon a recent paper concerning the feeding of colliery-horses, and it is possible, therefore, that the subject of stabling may attract equal attention.

Moreover, it may be advisable to shew that mining-engineers do give some thought to a subject which has recently engaged the consideration of several well-meaning persons, who without having any adequate means of informing themselves, have arrived at the conclusion that the treatment of pit-ponies deserves more of their sympathy than does that meted out to other people's horses. There is more cruelty and neglect on the surface than is to be found among the pit-lads of Durham and Northumberland, among whom it is, in the few instances discovered, severely punished. Cruelty is an extravagance which even the callous cannot afford.

On the writer's desk is a polished hoof, the silver-mounted inscription of which reads as follows:—

SWALLOW.

A 10 hands Shetland pony, was 5 years old when put to work down Kimblesworth pit on May 2nd, 1876. He ceased work 20½ years later on October 12th, 1898, aged 27 years. During the whole of his working life he never had a sick or sorry day, the 6 weeks' strike of 1879 and the 13 weeks' strike of 1892 being the only occasions on which he was idle. On August 8th, 1896, when 25 years old, he took third prize among 20 other pit-ponies shewn in Durham.

This is but typical of many examples which could be brought forward; and every colliery can usually boast of several animals whose life-records would speak equally well of honourable years of comfortable equine servitude, and of the kindness and humanity not only of those who manage the mines, but of the men also who wait upon the ponies in their stables and the lads who direct their labours in far-reaching underground galleries.

In no way can the comfort of a pony be better provided for, than in the home to which it has to return after its day's arduous labour is finished, and for this it must look very largely to the management of the colliery.

Horsekeepers may be anxious about the welfare of their charges, and may strive their best to attend thoroughly to their watering, feeding and cleaning, but the work will only be well done if the stable-arrangements are such as lend themselves naturally to such care and cleanliness.

The writer has seen all kinds of underground stables, from those extravagant in their cost, lavish in brick-arching and in many fancy contrivances, to those of a most primitive and ill-conceived design, but that which commends itself, is one which combines simplicity and economy with hygiene and comfort.

The ventilation should be so arranged that air cannot be wasted to the return-airway, and therefore the stables preferably should be placed as a branch-airway from the intake-airway, having the entrance and exit so constructed with "sconces" as to catch enough current to freely circulate through the stables, without unduly chilling the inmates, and return the air for further use in the mine.

Figs. 1, 2 and 3 (Plate XIII.) shew how the stable should be made. The gallery chosen should be lined on each side with brick-walls, AA, BB, in which any recesses, required for a variety of purposes, can be made where necessary. The leather-gear, however, is better preserved if left hanging in the air-current.

These walls may support, if the roof requires it, wooden or steel joists, C, which may be placed so as to mark the divisions between each stall. If the roof is very bad, arching sprung from side to side of the gallery may take the place of the joists. Hung from these joists or from the roof by means of chains, are swinging wooden partitions, D, which separate the stall of one pony from that of its neighbour. The moving partitions have the advantage that, while amply providing for separation, they permit free ventilation, and do not furnish any fixed corners for the accumulation of dirt or for the harbouring of vermin. Impatient animals cannot hurt themselves or their stables by kicking at sides which swing and give to the blow, while the gregarious nature of the horse is provided for by allowing him a view of his companions

on either side. The whole stable can be seen at a glance from one end, and is invariably sweet and free from strong ammonia-vapours. In any form of stable it is necessary to move quarrelsome animals until a neighbour to their liking is discovered.

The mangers are fashioned in cement, and supported by means of brickwork, E, at a height appropriate to the size of the animal. They should be as low as possible, and the writer thinks that the mangers shewn in the illustrations would be much improved by being placed lower. Iron bars, built in a few inches from each edge, will prevent the ponies from throwing out their food and wasting it. Water can be brought to each stall by means of an iron pipe, and each receptable should be provided with easy means of drainage for cleaning-out purposes. Horses thrive better if they have access to water at all times, and do not drink so much as when it is only given at long intervals.

An iron rack should run along the front-wall for the use of grass in summer, as it is to be presumed that hay will always be given chopped.

A large ring in the front of the manger with a weight, chain and collar, will serve to fasten up the horse, and great care should be taken that the chain is of a proper length. On no account should any animal ever be tied up without a running chain and ring, as in this way accidents occur from strangling, the horse getting his leg over the chain or rope and being cast in his stall.

The floor of the stable is the most important feature, and the writer has come to the conclusion that there is only one really good method of construction, in the absence of ordinary bedding material. Mr. Charles Hunting, in his paper on the feeding of underground horses, is responsible for the statement that only 1 in 10 lies down on brick, 2 in 10 on cement with sawdust, and 7 in 10 on wood. This, the writer thinks, can only refer to very large horses as he is not aware of a single case at the collieries under his charge of an animal which does not regularly lie down. The floor of each stall is made of the best possible cement-concrete, channelled in the ordinary way, with a fall of about 1 in 30 to a main-drain behind the stalls, having a fall of about 1 in 48. The concrete of each stall is further recessed, so as to contain a boarding of pitchpine, 5 feet by 6 feet by 1¼ inches thick, with ¾ inch interstices between the boards, and on these the ponies lie, high and dry.

The boards are made in halves, and are daily lifted for airing and cleaning, while the pony is out at work. The slope of 1 in 30 for drainage is not good for the flexor-tendons or hind-quarters of a horse, and it is possible to correct this by the use of boards, so that the horse may stand practically level thereon, while the cement below remains sufficiently sloped.

Actual experience has proved that such a floor lasts longer than any other, and that the condition of the ponies is much improved. The pitchpine lasts far longer than cement, under the wear of iron shoes, and floor-boards are still in use which were laid down when first designed some 5 years ago.

Another form of stall, shewn in Figs. 4 and 5 (Plate XIII.), is used where the roof is very short and would not allow of the excavation of a wide gallery. Each stall is really a loose-box, but in other respects the construction remains the same.

If possible, stables should be lighted by electricity, and kept whitewashed and disinfected. A curious belief has sprung up that dark stables injure the eyes of horses. It is a common fallacy that animals working underground become blind, and even so admirable a writer on the subject as Mr. James Fitzwygram says that if deprived of light, the optic nerve becomes paralysed and blindness results. This is all nonsense, although of course if a horse were never allowed to see, something of the kind might happen ; yet, under ordinary working conditions, neither the eyes of men nor horses are affected by working underground, other than by injury.

The pony that has been referred to as working over 20 years underground, was quite sound in his eyes, and exemplified the writer's invariable experience.

The cost of such a 14 hands pony-stall as has been described would vary, according to requirements, from £5 to £6 10s., but this does not include any stonework or other excavation.

One or two loose boxes for isolation-purposes should be provided, in positions where infection of healthy animals would not be easy, and any pony coughing or showing symptoms of even common cold should be removed thereto at once. These boxes

should be fitted with slings for severe injuries, as in winter time it is usually inadvisable to remove a pony from the warm mine to the cold surface.

Further hospital-accommodation should always be provided on the surface, and no newly-purchased animal should ever be put underground, until it has been under careful observation in an isolated place for one or two weeks.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) said that horsekeepers were too frequently labourers, who knew little of the requirements of a stable, and were not trained in stable-management, with the consequence that horses at some mines were neglected. Stables should have a tram-road at the head and at the tail of the horse, the former used entirely for feeding purposes and ventilation, and there was then no necessity for the attendant to go by the side of a restive horse, except for the purpose of cleaning the horse or the stall. When there were two roads, there was ample room for a good air-current to pass along each standing, and there was no necessity for the wooden partition, and he preferred to see each standing kept separate and distinct by brickwork.

It was not always possible to light stables electrically, but it was always possible to keep them whitewashed and disinfected. Unless several sets of stables were built some distance apart, it was very desirable that several loose boxes should be provided, for the isolation of infectious and supposed infectious cases. The horse was particularly liable to infection from its neighbours in the stable. All stables should have an ample volume of air passing through them, and should be kept strictly clean in every way, but he (Mr. Hewitt) was surprised to find that Mr. Blackett recommended that the air-current, after passing through the stables, should go straight into the mine-workings. In the Special Rules for the Midland mines-inspection district, this was prohibited, with the words "where practicable" added, and it was very desirable that stable-smells should not be allowed to pass along with the air-current and into the working-places. It was absolutely necessary in the majority of cases to avoid this, and the passage of ventilating-current direct into the return airway was an easy matter in most mines.

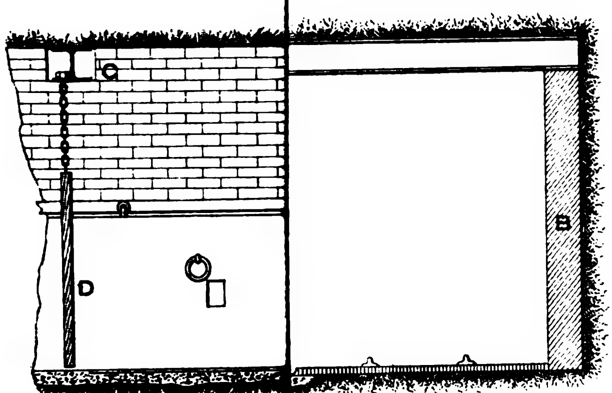


FIG. 2.—SECTION T NE F G OF FIG 1.

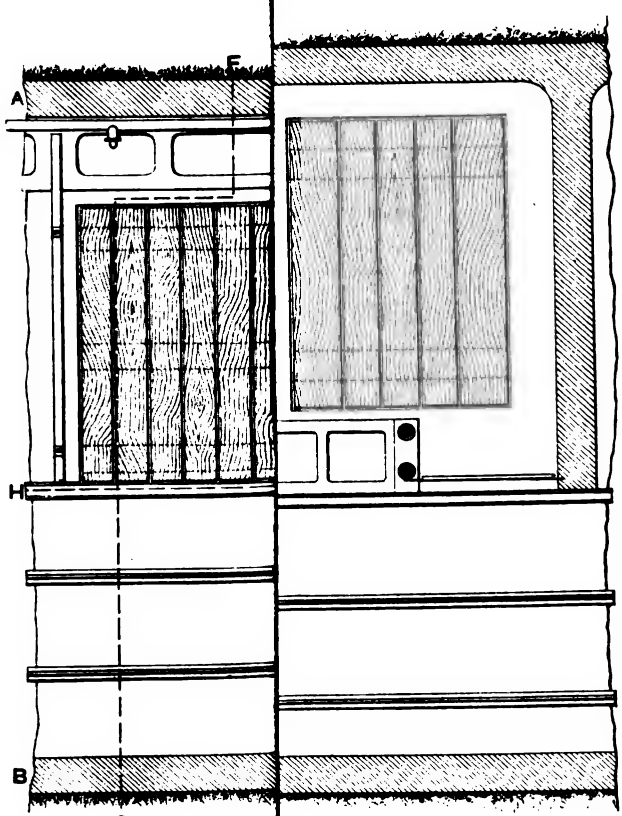


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FIG. 4.—PLAN

Mr. H. W. Hughes (Dudley) wrote that there were several points in Mr. Blackett's paper about which differences of opinion might reasonably exist. It certainly appeared preferable to ventilate the stable by an independent split of air and to return the more or less foul air direct to the upcast, without attempting to pass it into the workings. This split of air could be properly controlled by a regulator, leakage could be reduced to a minimum, and a smaller or larger quantity of air passed through the stables as desired. He preferred to send a moderate quantity of air through the stalls as soon as the horses had left in the morning, so as thoroughly to cool, purify and clean the stables, until they were quite sweet. The regulator was then nearly closed, and the stables allowed to warm again, ready for the horses at night. He had found that it was not advisable to send horses direct from the workings into a cold stable, but to bring them in warm and then slowly allow them to cool down. The question as to whether the stable should be placed in an elaborate arch or not was dependent upon circumstances, and it was the misfortune and not the fault of the engineer that he had often to waste money on brickwork. He had at one colliery a stable-arch inverted, the brickwork of which was 23 inches thick, but this was only put in after two other arches with thinner walls and inverts had been crushed. Mr. Blackett's statement that horses throve better if they had access to water, at all times, was an important one, and he believed that it was fully borne out by facts. He had always used a water-bosh to each stall, supplied by a pipe and provided with an outlet-drain at the bottom: this was generally closed by a plug, which enabled the stay of water to be let out each day.* In addition to ensuring a supply of fresh clean water, he also flushed out the stall, and this rendered cleaning more easy. Swinging partitions had all the advantages claimed by Mr. Blackett, but some of them were shared by fixed partitions. There was no need for a fixed partition to reach the floor or the roof: it might occupy the middle part, and then the ventilation was not impeded, there were little or no places for rubbish to accumulate, and each horse could see its neighbour. Sometimes with a swinging partition, he had found horses injuring themselves about the head by getting up awkwardly, and as a horse generally lay down on the same side each night he sometimes

* *Text-book of Coal-mining*, fourth edition, page 233.

pushed the partition on to his neighbour. Again, although they could not directly kick the next horse yet they could kick the partition on to him, and as it rebounded they also received a blow; and this often caused restiveness among the horses. The description which Mr. Blackett gave of the double flooring that he had adopted was most interesting. Everyone would admit that in the absence of bedding, which was rather out of place under ground, a horse would lie down better on wood than on any other material, but, unfortunately, wood-flooring became saturated with water, polished and slippery, making it a most difficult surface for horses to stand upon. He had tried fixing small wooden strips, in order to afford a foothold to the horses, but these sometimes were kicked off, and at others had the corners filled with dirt, so that they became useless. Such wooden casings were fixtures and placed directly on the ground, but by making the floor in two halves, so that it could be moved, and by elevating it slightly above the concrete-floor, Mr. Blackett seemed to have overcome these objections.

Mr. W. C. Blackett said that he once had been carried away with the idea that stables should have tram-roads at the head and tail, and several other adornments such as expensive brick-partitions. Experience, however, had taught him that much of this was unnecessary and a waste of money; there were far too many corners to harbour dirt, and perfect airing was an impossibility. He could not agree with those who had framed the Special Rules in the Midland mine-inspection district, so as to prevent the air from the stables being returned for further use into the mine. Horses and ponies did not breathe, while resting, say, more than 90 cubic feet of air each per hour, and to keep a stable of, say, 50 animals cool, it was necessary to circulate many times this volume. The ventilation of a mine contemplated the provision of air for men and animals, and while they were working they used much more air than when resting; yet if it was not considered objectionable to use air which had passed over the ponies in the workings, why should it not be allowed for important purposes after it had served the ponies, using as they did a less quantity when at rest? The most important purpose to be served by air in a mine was to "dilute and render harmless noxious gases," and to waste large quantities of air, merely because a small percentage

had once been breathed by ponies, seemed to him to be folly. Allowing that the small quantity of carbonic acid so produced was harmless, Messrs. Hewitt and Hughes would be in a further dilemma, inasmuch as if the stable-air was unfit for further use in the mine, then the stables must have been allowed to become too foul. The air-current, on the in-bye side of stables kept in a proper state, should have only a perceptible odour, and that largely from the use of small quantities of disinfectant. In those stables, where the current was wasted into the return-airway, he had observed certain incidents at nameless collieries, which introduced further objections. He had, for instance, known cases where a sort of war was carried on between the overman who wanted air for his workings and the horsekeeper who desired it for his animals. Sometimes the workings were foul, and sometimes the horses suffered.

A cold was almost an unknown thing in the stables under consideration, and, when such a thing had occurred, the animal was at once isolated, and seldom indeed had it ever happened that the complaint spread. Horses caught cold much more readily in dirty, close stables than in those that were well-aired, and for that reason he could not agree with Mr. Hughes, who apparently wasted most air in the day-time (when he presumably wanted it the most) by allowing more air to pass the stable-regulator when the ponies were out. And, in any case, the ventilation could be quite as easily controlled in returning the air to the mine, as in wasting it to the upcast shaft.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Blackett for his interesting paper upon an important detail of mine-management.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

DISCUSSION OF MR. SYDNEY F. WALKER'S PAPER ON "ALTERNATING CURRENTS, ETC."*

Mr. G. W. de TUNZELMANN (London) wrote that Mr. G. A. Mitchell said "he had seen it stated that while a pressure of 1,500 or 2,000 volts was fatal to life, with much higher pressures, such as 10,000 or 20,000 volts, there was not the same risk,"† and

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 451; and vol. xxii., page 566.

† *Ibid.*, vol. xxii., page 569.

asked for further information on this point. It appeared obvious to him (Mr. de Tunzelmann) that what was in Mr. Mitchell's mind must have been some statement referring to a fact which was well known to most station-engineers and others who had to deal in practice with high-pressure alternating currents, namely, that a voltage of about 2,000 was very much more dangerous to switch-board attendants and workmen than those of 10,000 volts or upwards. The reason for this lay in the fact that if a man accidentally grasped a conductor, contact with which would include him in an alternating circuit with a pressure of, say, 2,000 volts, he would feel little effect until his hand was actually in contact with the conductor, when the resulting contraction of the muscles would prevent him from letting go, ensuring the best contact possible under the circumstances, and the prolonged action of the current. At 10,000 volts, and still more at higher pressures, the hand would be strongly repelled before actual contact took place, to such an extent that contact was extremely unlikely, and, therefore, the workman might very possibly escape with a severe burn, due to a momentary arc being formed between his body and the conductor. If actual contact took place, the hand would be fixed round the conductor as in the case of lower voltages, and, given similar conditions with respect to the two contacts necessary to complete the circuit, a greater current would pass in the case of the higher pressures, and therefore there would be a still greater probability of a fatal result.

Mr. Sydney F. Walker (London) wrote that he could hardly agree with the view set forth by Mr. de Tunzelmann, nor did he think that the experience which he gives is a common one: he would call it a most uncommon experience. His experience, and, he believed, that of most electrical engineers engaged in practical work, is that the current, on touching a conductor, is felt immediately, unless the hand has matter on it which protects it. He had received many smart shocks from a 200 volts alternating circuit, and with a very slight touch. Also supposing that a workman's hands were protected by caked dirt, or horn, so that he would not feel comparatively low pressures, higher pressures, up to a certain figure, would only have the same effect upon him as lower pressures have upon individuals not so protected: this would apply to what may be termed "low high pressures," those of, say, 500 to 2,000 volts. The greater number of fatalities from

2,000 volts circuits have been among workmen. There is one point in connection with this matter, on which Mr. de Tunzelmann is correct, and that is the time-factor. Time, it is now well established, has a most important bearing upon the result, and if a man does catch hold of a 2,000 volts service, it is quite correct to say that he cannot easily let go and is killed by the passage of the current for a given time. But this is also true, in many cases, of a 500 volts continuous-current service, and of a 200 volts alternating-current service. It is hardly correct to say that the 10,000 volts service would repel a man's hand; but it will come out to him, and give him a nasty shock, accompanied by an equally nasty burn, without the necessity of his touching the conductor. Surely that can hardly be called safer. The meaning of this is, with 10,000 volts alternating, the maximum pressure of which is 14,400 volts, the pressure is sufficient to enable the spark to pass across a short interval between the conductor and a man's hand. The high pressure breaks down the resistance of the air-space. So far as he knew, the only possible explanation of the report referred to by Mr. Mitchell, that high pressures are safer, is the fact also referred to at Glasgow, that high pressures are perfectly safe, provided that they are alternating, and at very high frequencies. He (Mr. Walker) might mention that alternating currents of very high pressure and very high frequency are being used in London for medical purposes—in the treatment of cancer and some other diseases. The pressures used cannot be less than 100,000 volts, and the frequencies probably several millions per minute, as against the 2,400 per minute, or 40 periods per second, of modern alternating-current practice.

DISCUSSION OF MR. A. RATEAU'S PAPER ON "A REGENERATIVE STEAM-ACCUMULATOR, ETC."*

Mr. A. Rateau wrote that steam-engines, working intermittently, such as winding-engines and rolling-mill engines, even when they are provided with condensers, consume a very large quantity of steam, the consumption being often four times as great as that of an engine working continuously. The principle of the Rateau system is to fit engines working intermittently with a condenser and to cause the steam that enters the latter to do

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 613.

work in a turbine, regulating the flow of steam by interposing between the turbine and the intermittent engine, an apparatus which can be called a steam-regenerator.

Taking as an example, the plant nearly completed at the Bruay mines, the steam-regenerator consists of 3 vertical cylindrical vessels of wrought-iron, within which are placed a series of cast-iron plates, the upper portions of which form a bason. These vessels communicate on one side with the cylinders of the winding-engine and on the other side with the turbine. When the winding-engine is at work, the steam enters the regenerator in quantity greater than the mean consumption of the turbine; and the excess is condensed in the cast-iron basins by reason of a slight increase of pressure within the apparatus, a pressure practically equal to that of the atmosphere. The temperature also rises, but this increase is limited to a few degrees on account of the large mass of cast-iron (40 tons) which forms, so to speak, a heat fly-wheel. When, on the other hand, the winding-engine is stopped, the water condensed in the basins is given off again in the state of steam, owing to the heat which has been stored in the cast-iron during the preceding period. The turbine is thus fed continuously by a flow of steam subject to small variations of pressure, presuming that the periods of stoppage of the winding-engine are not too prolonged, and, of course, easily brought to an almost uniform pressure, by means of the regulating valve and governor.

The turbine consists of several wheels, in series, mounted upon the same shaft, their diameter being 35·43 inches (0·9 metre). It receives steam from the regenerator at a pressure very slightly below that of the atmosphere, so as not to interfere with the escape of steam from the winding-engine. From the turbine, steam enters the condenser, in which a vacuum of from 24½ to 25½ inches (62 to 65 centimetres) of mercury is maintained. Under these conditions, the turbine, making 1,600 revolutions per minute, will develop a force of 300 horse-power. This force is utilized to work a double dynamo keyed to the same shaft, the current from which goes to the main switch-board, to be distributed on a three-wire system.

Whenever the winding-engine stops for a somewhat too lengthy period, precautions must be taken that the turbine, which supplies the electric current, should not stop. This possibility

has been prevented by fitting the turbine with an arrangement which automatically passes live steam directly from the boilers. This is so regulated that, for example, if the turbine works at a pressure of 0·90 atmosphere absolute, steam will be admitted until the pressure attains to 0·95 atmosphere by means of a special reducing-valve.

The Bruay turbine has been submitted to exact tests in the shops of Messrs. Sautter-Harlé & Cie. (where the machine was built), running at 1,600 revolutions with a vacuum in the condenser of 24½ to 25½ inches (62 to 65 centimetres) of mercury, and a pressure of 13 pounds per square inch (0·9 kilogramme per square centimetre) at a consumption of 40 pounds (18 kilogrammes) of steam per hour and per electric horse-power at the terminals of the dynamo. If the winding-engine takes 100 pounds (45 kilogrammes) of steam per effective horsepower-hour (calculated upon the coals raised), the turbine will produce, in the form of electric current, 2½ horsepower per effective horsepower utilized, or, say, 250 horsepower, if the useful effect of the winding-engine be 100 horsepower. With a pressure of 1 atmosphere, and a vacuum of 26½ inches (67 centimetres) of mercury, the consumption of steam in the turbine will fall to 30 pounds (13½ kilogrammes) per horsepower-hour. With live steam at 114 pounds per square inch (8 kilogrammes per square centimetre) utilized direct, the steam-consumption would be less than 18 pounds (8 kilogrammes).

The advantage of a series-turbine is to utilize the whole of the fall of pressure down to the pressure of the condenser itself. A turbine, such as that of Bruay, gives an efficiency, which is almost double that of the third cylinder of a triple-expansion engine.

DISCUSSION OF MR. G. R. THOMPSON'S PAPER ON "THE CONNECTION OF UNDERGROUND AND SURFACE-SURVEYS."*

Mr. S. J. Pollitzer (Sydney, New South Wales) wrote that, in his experience, there was no case in which the magnetic-needle method should, for even the shortest connection, be employed, as the variation of the needle at each plat was different and occasionally by many degrees, and none of the plat-variations can be

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 519.

made to agree with the one taken on the surface. In describing the transit-method, Mr. Thompson omitted to give some explanations which were required in order to make the operation complete, although he correctly transferred an azimuthal line from the bottom to the surface: however, the bottom-line had no initial point with its co-ordinates as yet, whereas the one on the surface had it in the vertical axis of the instrument. If he had said that he marked a third point at the bottom, with the telescope truly vertical, the operation as regards horizontal projection would have been complete; and to be quite complete, he might have stated how he ascertained the depth of his bottom-line below the surface. With regard to his minute calculations on the plumb-line method, Mr. Thompson was correct as to the calculations: they were, however, not always necessary in practice, if the disturbing elements could be removed, as he (Mr. Pollitzer) showed in his paper.*

Mr. G. R. THOMPSON (Leeds) wrote that it is interesting to have Mr. Pollitzer's statement regarding his experience with the magnetic needle, and his emphatic testimony to its erratic behaviour underground, which shows that great care should be taken to be perfectly sure of the absence of local attraction before trusting a magnetic survey. When, however, local attraction is known to be absent, and the underground sights are very short, a magnetic survey may be the best that is available with any reasonable amount of labour. In the introduction to his (Mr. Thompson's) paper† he pointed out the necessity of determining a common co-ordinate point and the depth, as well as the common meridian, but the paper itself was restricted to the consideration of the degree of accuracy attainable in determining the latter. The details for conducting the different operations are admirably described in Mr. Brough's work on *Mine-surveying*, while a recent paper by Mr. E. H. Liveing‡ gives every detail in the practice of the transit-instrument method for a deep shaft. He, therefore, gave as little detail of the different processes as possible. Regarding the plumb-line method, he would hardly look upon his calculations as minute: as they are only such as to determine the equilibrium-point of a swinging pendulum, and consist in simply taking the

* *Trans. Inst. M.E.*, 1902, vol. xxv., page 17.

† *Ibid.*, 1901, vol. xxii., page 519.

‡ *Ibid.*, 1899, vol. xviii., page 65.

average reading. By putting on differently-weighted plummets, he altered the conditions of the experiment and determined whether there was any disturbance or not. Should not this proof always be given before its absence is assumed? He looked forward with interest to the publication of Mr. Pollitzer's paper, to see in what manner he removes the disturbing elements. At the Tamarack mine, recently, it was found that two plumb-lines were about 1 inch farther apart at the bottom than at the top, the depth of the shaft being 4,250 feet. After various experiments, it was concluded that the disturbance was due to air-currents and the shaft-top and all openings were closed, when the lines were nearer together, how much nearer the brief note to which he had access did not state: neither could he judge how much the total disturbance of either of the plumb-lines varied from the true vertical. Mr. Hoskold doubts the reliability of plumb-lines for deep shafts; but is it not in such that well conducted plumb-line methods may be expected to compete with telescopic ones? In the case of a dry rectangular shaft, where a possible plumbed base-line may be from 20 to 24 feet long, while the transit base-line could only be 6 to 7 feet long in the same shaft, and where ventilation can be cut off for the time being, he thought that accurate plumbing could be done and results obtained, which for a deep shaft could only be exceeded in accuracy by a very powerful transit-instrument. The accuracy of the result, moreover, would not be left to chance, but freedom from disturbance would be proved; the method is, however, tedious. The power of the telescope must increase for deeper and deeper shafts when the transit-method is adopted. Mr. Hoskold even admits that the telescope on his 5 inches theodolite is not sufficiently powerful for deep shafts, while claiming for his 6 inches instrument that it is. It would be interesting to know in this connection the power of telescope that the makers place on the respective instruments. He intended the error which he fixed for pointing the telescope to be the outside limit, and was prepared to have it reduced somewhat in the discussion; but he was hardly prepared to concede that in practice it would be more imaginary than real. The fact of a very accurate holing having been made at the Severn tunnel does not in any way prove this, for the conditions were those in which great magnification was not required. A shallow tunnel-shaft is by no means the same as a deep mine-shaft.

Mr. VICTOR WATTEYNE (Brussels) wrote that the compass is most generally used in Belgium for underground surveys. In addition to the convenience of its use, the instrument has the valuable advantage of not continuing the angular errors which may have been committed. In fact, the compass indicates, each time, a direction independent of those which have been observed previously; an error, committed in a previous sight, cannot, therefore, influence this direction; and has no other consequence than to displace the starting-point of the latter. The trace of the survey would certainly be somewhat different from what it ought to be, but it would remain parallel to the true trace, and would only depart from it by a quantity proportional to the length of the sight in which an error had been made. It is different with the thodolite, where an error of angular measurement made at the start is carried throughout the entire traverse, and if this is very long, an error of 1 minute, for example, may have the consequence of causing considerable error in the final point from its true position. At the surface, this objection is generally less, for one has usually several points, which can be sighted from different stations, and one can thus verify whether any of the sights have been taken wrongly. In a mine, on the other hand, these methods of verifications are very rare, or in the largest number of cases do not exist at all. This superiority of the compass is well known, and if he (Mr. Watteyne) mentioned it here, it was because it seemed sometimes lost sight of or not appreciated at its full value, in discussions on the comparative advantages of the compass and the theodolite. It would seem, therefore, that preference should be given to the use of the compass in underground surveys; and this would be the case if one could be certain that the direction given by the compass at the bottom of the shaft is really the true direction. Unfortunately, this is far from being the case, and the causes of error are numerous. One can avoid the consequences of variations of the magnetic needle, by taking at the surface identical compass-observations upon a fixed direction, which is well known, at the same time as the underground survey is being made, and by carefully noting the declination during the whole time that the survey lasts. But a cause of error that cannot be avoided is that which results from the fact that at the same moment the declination might be different in the mine and at the surface, that is to say, that the azimuth indicated by the compass would not be the same if one sighted at the same moment in the mine and at the surface. It is probable that

these differences of declination between the top and bottom exist, and also that these differences vary with the depth.

In a recent paper, written jointly with his colleague, Mr. Libert, it is stated that in examining the plans of different collieries which work regular seams, it has been noticed that the same drifts, traced according to surveys made with the compass at different depths, assume on the plans positions making a certain angle with each other, and that this angular divergence is always in the same direction (Figs. 1 and 2, Plate XIV.).* Let P be a shaft, and A B C a coal-seam worked successively at depths of 900, 1,200 and 1,500 feet, the levels of one winning becoming, subsequently, the return-airways of the winning immediately below it. Plans have been made by means of the compass of the levels of each winning. The plan of the level of the 900 feet winning as surveyed by the compass is AA; and at 1,200 feet, the compass gives BB as the direction of the level. If the working-face, T, is afterwards surveyed as far as the return-airway, which, as above said, is the old level, AA, it will be found that this airway does not pass through AA, but through A'A'. The same deviation happens at the 1,500 feet winning, where the return-airway is found to occupy the position B'B' instead of the position BB. As A'A' is identical with AA, and B'B' is the same place as BB, some error has manifestly been committed. What is the cause of it? There might evidently have been some negligence in survey, but if there were no other causes it would be very extraordinary that these negligences should always produce deviations in the same direction. It must also be remarked that the plan of the cross-measures drifts has undergone deviations of the same kind, and that the three roads, PA, PB and PC, supposed to be in the same identical direction, have taken, in the plan, positions which are not vertical, one above the other, as indicated in Fig. 2 (Plate XIV.). The explanation of these errors, which are produced even when working with the greatest care, is easily found if one admits that the declination of the needle is different at 1,500 feet from what it is at depths of 900 feet or 1,200 feet. This difference will necessarily result in the lines CC, BB and AA, which are in reality parallel (as would result from the hypothesis of a perfectly regular deposit), being indicated by a compass-survey in different directions. The variations of declination with depth should not be a matter of surprise,

* *Annales des Mines de Belgique*, 1902, vol. vi., page 896; and vol. vii. page 99.

as it is indeed well known that isogonal lines, that is to say, lines along which the magnetic declination is the same, are not meridian lines, nor are they straight lines or regular curves, but on the contrary sinuous lines, at times very irregular. It is not surprising that such lines should not be projected into the interior of the earth in absolutely vertical surfaces. The contrary seems more probable, and it may thus be that in advancing vertically into the earth one passes from one isogonal surface to another, and that consequently there should be a different magnetic declination. If, indeed, one considers that isogonal lines or rather surfaces are shifting at each instant, and that their sinuosities are different, from one point to another, it may be concluded that the law of the variation is different for each locality, and that it may undergo modifications from one instant to another. It follows from what has been said that a knowledge of the methods and of the instruments to be employed in order to establish without the help of the compass a connection between the mine and the surface is of the highest importance. He (Mr. Watteyne) might add that in a mine where it is of importance to have exact plans, it is indispensable to determine at each level, by methods independent of magnetic perturbations, that is to say, without the aid of the compass, a direction, referred to a well-known direction on the surface, which would serve as a base-line for all plans, made at that level, whether such plans were made by the compass, by means of the theodolite, or by any other instrument.

DISCUSSION OF MR. H. D. HOSKOLD'S PAPER ON "A NEW CIVIL AND MINING ENGINEERS' TRANSIT-THEODOLITE, ETC."*

Mr. S. J. POLLITZER (Sydney, New South Wales) wrote that Mr. Hoskold's new transit-instrument was certainly a most excellent idea, very carefully designed, and he deserved great credit for it. Mr. Hoskold provided his eye-piece with a diaphragm for the purpose of measuring distances, and this was the very best thing that he could have done; he adjusted his instrument on the top of a traversing-stand with various adjusting screws, until his vertical spider-line would exactly bisect the two lighted points on the strained copper-wire at the bottom of the shaft. Here was the same identical omission as that made in Mr. Thompson's

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 536.

To illustrate Mr. V. Watteyne's "Notes on Compass-surveys."

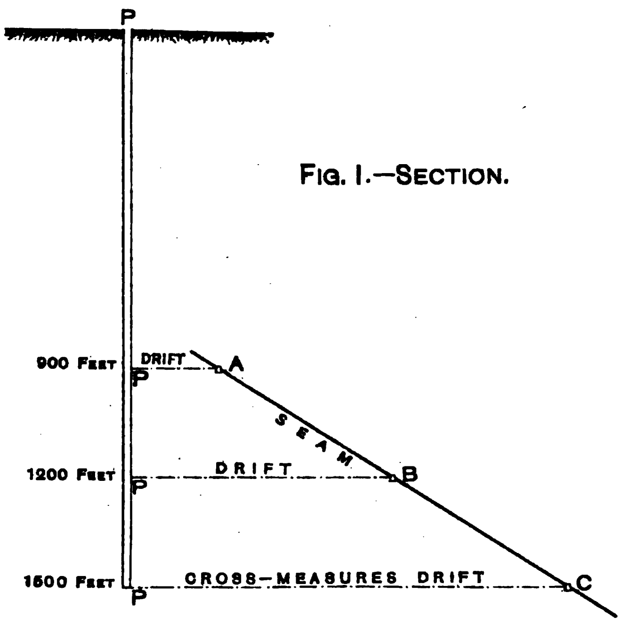
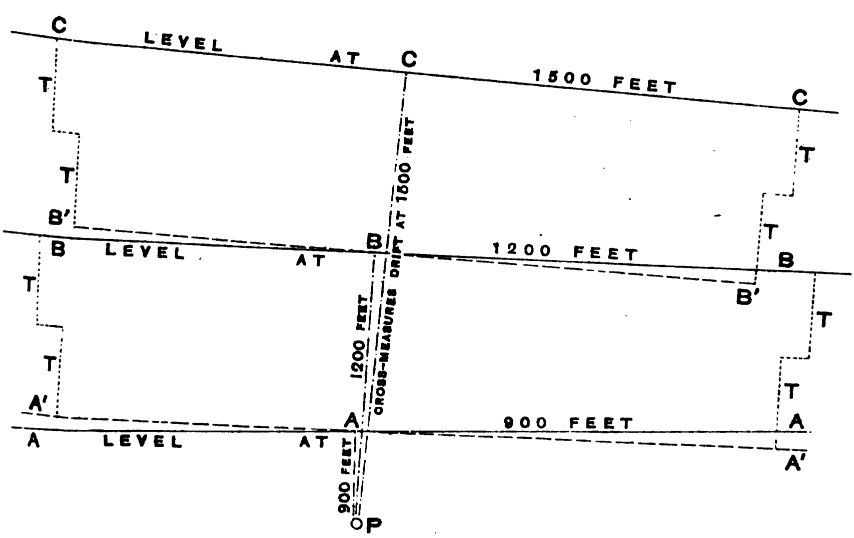


Fig. 1.—Section.

Fig. 2.—Plan.



paper, with the difference that it was more serious in the instrument, because it was provided with a diaphragm which was not used; moreover, as explained by Mr. Hoskold, it could not be used. To make appropriate use of the diaphragm, the operation ought to be augmented by shifting, afterwards, the two lights, along the stretched copper-wire forward or backward until each was also bisected by the horizontal lines of the diaphragm. Could Mr. Hoskold say, supposing a depth of 3,000 feet was observed, that the two horizontal lines of the diaphragm would bisect two points within the narrow limits of the shaft? or, were there different diaphragms attached to the instrument for observing at different depths? The rack-and-pinion movement of the telescope to obviate the use of high Y standards, on account of vibration, was rather too delicate to avoid eccentricity of the telescope, since the possible vibration of a couple of inches of the higher Y was more imaginary than real. Another important matter, which Mr. Hoskold did not explain, was:—When using the theodolite for ordinary surveying, how was the instrument centred over a point, with a cylindrical hole, 1 inch in diameter, in its centre? Doubtless he had something to fill it, provided with a hook for the plumb-bob.

There is an inherent defect in the principle of the construction of theodolites in general, which ought to be remedied. That is, when an instrument had been carefully centred and levelled, the surveyor thought that the vertical axis of the instrument was the mathematical prolongation of the plumb-line. This, however, was not always the case, especially when working in hilly country, where the parallelism of the two parallel plates could not always be maintained; the upper plate naturally was always horizontal, but not the lower; and it often happened that the two plates were $\frac{1}{8}$ inch more apart on one side than on the diametrically opposite side, and the hook for the plumb-bob was fixed to the lower plate, which was not level, throwing it out thereby from the vertical axis of the instrument by an eccentricity, $X = y \sin \alpha$; consequently, the two plates should be as much as possible parallel and in an horizontal position, and the distance between the hook-eye and the centre of the ball-and-socket motion should be as little as possible. But with the existing system of instruments, the latter could not be much reduced, so there is room for improvement in the mode of fixing the hook.

In his opinion, however, Mr. Hoskold's new instrument was

really a most superior invention for the purpose of surveying vertical shafts; but in shafts on the underlay it would be out of place, without additional improvements for that purpose.

Mr. H. D. Hoskold (Buenos Aires) wrote that it was intended that his paper upon his new transit-theodolite should be written as concisely as possible, leaving some minor points to be inferred. It was gratifying, as also interesting, to find that Mr. S. J. Pollitzer (Sydney, New South Wales) had appreciated and kindly expressed a favourable opinion upon the new instrument in question, and the writer desired to thank him for his attention.

In reference to the question as to what depth a short base-line may be observed from the top of a shaft, it may be stated that the hole in the vertical axis of the instrument is sufficiently large to enable an observer to take a vertical angle through it up to 3 degrees, or 1 degree 30 minutes each way from the perpendicular line. If, therefore, two illuminated marks were placed, 12 feet apart, at the bottom of a shaft, they could be bisected with the vertical spider-line in the focus of the telescope, under the above-named angle, at a depth of 229 feet; and, for the same length of base-line, under a diminishing vertical angle, to any depth within the power of the telescope. If the base-line between the two illuminated marks were to be diminished to suit the narrow conditions of a shaft to, say, 9 feet, then the minimum distance or depth would be diminished to about 171 feet; and to be continued in depth, according to the principle cited in the former case. For a depth of 3,000 feet and similar length of base-line, the angle subtended between the illuminated marks would be very small, still the bisection would be as perfect as at lesser depths, with a probable difference that it may be convenient to increase the illuminating power with the depth. There is no more difference or difficulty in sighting two points at the bottom of a shaft a given distance apart, than there would be in sighting to two points placed an equal distance apart on an upright illuminated pole at night upon the surface, without the necessity of requiring the aid of different diaphragms.

The socket, or sleeve, forming part of the horizontal axis, is, as already noted in his paper, made sufficiently long to provide for a smooth undeviating longitudinal motion when the middle part of the telescope slides in it. This part of the telescope-tube, as also the whole, is turned as mathematically correct, in

reference to its optical axis, as mechanical art could make it, consequently there is no more "eccentricity" in it, than there is in the vertical axis upon which so much art is expended to render it as free from eccentricity as is possible. In very large surveying instruments this is rigidly tested by the readings of three equidistant verniers. It must further be observed that the telescope does not revolve vertically in the socket or about its optical axis, but is only moved forward or backward by its rack-and-pinion screw. The proof of accuracy in this motion is to focus the telescope upon a fine distant object, giving motion to the telescope in its sleeve, and observing whether the vertical spider-line continues in contact with the distant object. After various rigid trials, it was found that no deviation whatever existed.

To aid in placing the instrument over a fine station-point, the usual hook for suspending the plumb-line is screwed into a metal plug, which also, in its turn, is screwed into the bottom of the hole of the axis.

The instrument is not mounted upon parallel plates, but upon a triangular levelling base-frame carrying three levelling-screws which are locked into another triangular frame which is screwed upon the tripod-head. Upon this latter levelling-frame, a low traversing-plate with a circular clamp is mounted, forming the central part of it, by the aid of which the theodolite, with the hook and suspended plumb-line, is made to traverse a given distance from the centre, so that every facility is afforded for centring over a fine station-mark.

The common tripod-stand employed in all surveys, except when sighting down a shaft, is what is termed an open one, with a large hole cut in the table-plate of the head, and inside the upward projecting male-screw to which the triangular levelling-frame is screwed. Consequently, when the instrument is centred over a station, the fine point of the suspended metal-bob, the plumb-line, and the centre of the vertical axis of the instrument, are all in the same vertical plane. The common defects inherent in ordinary constructed instruments referred to by Mr. Pollitzer are, therefore, eliminated altogether.

In levelling ordinary surveying-instruments with parallel plates and four conjugate screws, a strain is put upon the vertical axis, and this strain is augmented when there are high and heavy Ys, a proportionate long telescope, vertical circle and other appendages, all of which render such an instrument too top-

heavy and awkward, and certainly liable to vibration in windy and mountainous regions. The tendency of each pair of levelling-screws, between the parallel plates, is to produce opposing and straining forces with a corresponding expansion of the weaker parts of the metal forming the small diameter of the screws, with a resulting proportionate derangement of the spirit-bubbles after the instrument has been levelled; besides, as Mr. Pollitzer observes, other defects appear when working in "hilly country." Any retouching of the screws, for fine levelling, must be done with the two hands, for the screws frequently are jammed, and difficult to move when the levelling-plates are displaced from their parallelism; but considering that when a triangular levelling-frame and three screws are used, such difficulties cannot exist, because each screw is independent of the other, and after the first levelling, if any small displacement of the spirit-bubbles occurs, it can be readjusted by turning one of the screws. For constant hilly work, a tripod with sliding legs would be most convenient, one of which may be shortened to suit the inclination of the mountain-side and so facilitate the setting up and levelling.

Additional facility is provided for centring the writer's instrument over fine station-points, and this is effected by placing the telescope to look towards the nadir, setting it up level over the station, and then, by the centring apparatus, bringing the cross of the spider-lines to bisect the fine point in the station; but, for this object, a suitable additional eye-piece must be provided, etc.

Mr. Pollitzer thinks that the instrument under discussion could not be applied "in shafts on the underlay," because the lowness of the Ys does not permit of observing large depressed angles; but this apparent difficulty is overcome by slipping over the objective end of the telescope a properly prepared metallic tube, similar to but longer than an ordinary sunshade, the outer end of which is closed, with an opening cut in the under-side large enough to admit rays of light, which would strike against a large reflector or glass-prism placed in the tube opposite to the opening and at an angle of 45 degrees. If, therefore, an electric lamp or some other illuminated point were to be placed at the bottom of the underground incline, or under-lay shaft, and the telescope brought into that direction, and sufficiently elevated for the reflector to receive the rays of light from the lamp, these would be reflected to the focus of the telescope, and bisected by

the vertical spider-line, and the operation would be effected as efficiently as it would be if observed directly through the telescope. This reflecting apparatus or attachment is termed the "complimentary-angle measurer." Any surface-line may be connected in this manner to the line passing through the underlay shaft, under any depressed angle down to the perpendicular. When observing an illuminated point as above described, the angle of depression is easily determined by employing the reading on the vertical circle, as one of the elements: that is, the angle thus obtained is measured from the perpendicular line, consequently it becomes the complement of the angle required, or that formed between the horizontal and the underlay shaft-line. Evidently Mr. Pollitzer is labouring under the impression that he (Mr. Hoskold) intended his new transit-theodolite, under notice, to be used in narrow, low, zig-zag inclined roads in mines; but considering that the largest form of the instrument is constructed with 6 inches divided circles, a long and powerful telescope, it is more particularly adapted for extensive land-surveying operations, as also in large mine-headings, railway and other tunnels, and in making a connection between underground and surface surveys. However, the smaller sizes, with 4½ and 5 inches circles, mounted upon low tripod-stands, are well-suited for general underground-surveys, and may be so employed with the greatest facility and efficiency. In all such cases, the greatest speed and accuracy would be obtained by the use of three interchangeable tripod-stands, with suitable lamps.

The small apparatus attached to the eye-piece for measuring distances consists of a micrometer with divided circle, and not a simple diaphragm with stadia spider-lines fixed upon it as Mr. Pollitzer thinks. This micrometer can be made to read very fine angles down to either 1 or 2 seconds of arc, consequently distances can be determined with great facility and accuracy by the rule already given in the writer's paper published in the *Transactions*.*

He (Mr. Hoskold) had already explained that he had designed a special traversing-stand,† upon which the new instrument is mounted when a perpendicular sight is taken down a shaft. This stand has been completed, and it is proposed soon to give, in the *Transactions*, a short notice of its use.

* *Trans. Inst. M.E.*, 1899, vol. xix., page 208. † *Ibid.*, 1901, vol. xxii., page 550.

DISCUSSION OF MR. DUNBAR D. SCOTT'S PAPER ON "MINE-SURVEYING INSTRUMENTS."*

Mr. LUDWIG TESDORPF (Stuttgart, Germany) wrote that he had read, with great interest, Mr. Dunbar D. Scott's paper on surveying instruments. In the description of the orientation-instrument,† it had been assumed that in every measurement the additional objective lens must be employed.‡ This would certainly be awkward and take time, and might lead to a derangement of the line of collimation. He therefore appended an exact description of the mode of use of the instrument. The orientation instrument, shown in Fig. 1, is specially distinguished from other types of instruments with a declination-needle, by the fact that the coincidence of the north-south lines with the axis of collimation can be directly tested from time to time by means of the telescope, and this constitutes its special feature. The case of the compass-needle rests upon a support that can be adjusted in all directions, and the former can be readily removed in order to clean the magnetic needle. By a suitable device, it is secured in an exactly true concentric and diametral position after being replaced. The magnetic needle is also arranged for reversing. According to the size of the instrument, the needle has a

FIG. 1. ORIENTATION INSTRUMENT.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 575.

† *Ibid.*, 1902, vol. xxiii., page 598.

‡ This is, however, by no means necessary.

length of 6 to 8 inches (15 to 20 centimetres), the diameter of the limb of the horizontal circle being always equal to the length of the compass-needle. This needle is beam-shaped, and at both ends fine lines are engraved on it (Fig. 2) by means of a diamond. The cap consists of a highly-polished garnet or ruby. The removable front lens is only employed for the adjustment of the compass-needle; and during other observations it is not used, but remains in the box.

After the instrument has been adjusted, measurements are made as follows:—The zero of the vernier is first set to the zero of the horizontal limb; then the body-piece of the instrument is turned until the magnetic needle swings freely; by means of a hand-lens the needle is then set in the magnetic meridian by causing the fine line, *a*, of the magnetic needle to coincide exactly with an equally fine line, *b*, engraved on the side of the compass-box (Fig. 2). The line, *b*, is brought into coincidence with the axis of collimation, when the instrument is being adjusted by means of screws, *c* and *d*.*

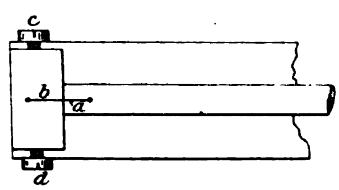


FIG. 2.

Measurements are performed with this instrument with great rapidity and accuracy. It is only necessary to bring the lines *a* and *b* (Fig. 2) into coincidence in order to be sure that the line of collimation of the telescope shall lie exactly in the magnetic meridian. Instruments of this type are made as may be desired with or without vertical circles. Fig. 1 shows the instrument with a vertical circle, this latter having covered divisions. The second removable and easily adjustable eccentric telescope is employed especially for zenith- and nadir-observations. For illumination at night, a lamp is placed at one side, which throws light, through the perforated trunnion of the telescope, upon a very small mirror, 0·08 inch (2 millimetres) in diameter, and thence it is reflected into the field of view, so that even by night the cross-wires of the eye-piece appear dark black on a bright ground.

* As with other instruments, all the angles are reduced to magnetic north or zero, but it can be effected much more exactly with this than with other types of instruments.

Prof. H. LOUIS (Newcastle-upon-Tyne) ventured to think that Mr. Scott had failed to do justice to the real merits of the three-tripod system of surveying, which is largely practised in this country and especially in coal-mine surveys. Three tripods exactly similar are used, the middle one carrying always the dial or theodolite, while the first and last carry signals (which in fiery collieries are of course safety-lamps). When the back-sight has been taken, the last tripod is moved forward by an assistant and levelled approximately, and the instrument is then removed to the tripod, which is now in the middle, the lamp (or what was the fore-sight in the previous sight) being brought back to give the next back-sight, and so on. By this mode of working the rate of surveying is quite doubled, which is a very important consideration in a busy pit working at high pressure, and the work is at least as accurate and probably more accurate than it is when only one tripod is used. He (Prof. Louis) did not quite understand whether Mr. Scott's sentence, "the essential advantage of the system leaves no permanent points for future reference,"* was intended to be laudatory or condemnatory of the three-tripod system; in his (Prof. Louis's) opinion it was one of the decided advantages of this method that it enabled stations to be sighted with the utmost accuracy without requiring permanent marks to be put in at each station, as he was opposed to the multiplication of such permanent marks, which only led to confusion, unless they were restricted to points where they would be required subsequently for the starting or closing-points of branch-traverses. If a check-traverse has to be made at any future time along the same roadways, it is rather an advantage that the second traverse will employ intermediate stations different from the first one.

With regard to Mr. Scott's remark that the rack-and-pinion was in use for both limbs of a theodolite down to the end of the eighteenth century,† it might be interesting to record that the first theodolite owned by Prof. Louis was a London-made plain theodolite, made, apparently, subsequent to 1850, in which both the horizontal limb and the vertical semicircle were worked by rack-and-pinion, although the bodypiece was fitted with the usual clamp and tangent-screw.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 590

† *Ibid.*, page 595.

He (Prof. Louis) quite endorsed Mr. Scott's condemnation of magnetic-needle surveying as only "applicable to the most ordinary kinds of work,"* and utterly failed to see what advantage could be hoped for from such an elaborate instrument as the Tesdorpf-Breithaupt orientation instrument. What was the use of reading the position of a magnetic needle to 20 seconds, when its diurnal variation might exceed 8 minutes? This was surely an affectation of accuracy that could serve no practical purpose. It ought to be clearly understood that the use of the magnetic needle should be restricted to filling in details of surveys, and to any other survey-work in which errors up to a quarter of a degree might be disregarded. Even for such work, it is probable that the plane-table deserves preference over the miner's dial, as the former instrument is quite as rapid and quite as accurate as the latter, and avoids the risk of serious error due to some unknown disturbing magnetic influence.

He (Prof. Louis) would be glad to know what advantage, if any, Mr. Scott considered the Brunton hand-compass to possess over the prismatic compass; there are several types of combined prismatic compass and clinometer that appear to do everything that the Brunton compass does, at least as well as that instrument. He (Prof. Louis) had tried to use the Brunton compass, but found that its range in taking bearings in hilly districts appeared to be so limited, that he had given it up.

Finally, he (Prof. Louis) was sorry to see that Mr. Scott used the word "tachymeter" instead of "tacheometer"; he ventured to think that the latter form had the sanction of priority as well as perhaps being the more correct etymologically.

Mr. H. D. Hoskold (Buenos Aires) wrote that as he had already written three papers upon a similar subject, provoked by Mr. Scott's paper on "The Evolution of Mine-surveying Instruments," those of others, and resulting discussions,† he thought that the subject-matter had been so far treated as to leave but little or no room or necessity for going over the ground again, and introducing the same subject in a new form in other places.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 598.

† *Transactions of the American Institute of Mining Engineers*, 1898, vol. xxviii., page 679; 1899, vol. xxix., page 931; 1900, vol. xxx., pages 783 and 803; and 1901, vol. xxxi., pages 25, 56, 716, 884 and 921.

It was, however, evident that Mr. Scott considered the matter from another stand-point, and he was to be highly commended for his researches into the dusty records of the past, and in bringing forward in his American and British papers the results of his labours. His American paper received a considerable amount of attention from various professional veterans, whose independent papers and discussions exhibited their appreciation of the great value and importance of mine-surveying. It was, therefore, to be hoped that his British paper, which was now under discussion, would receive equal attention from British mining-engineers, and, in that sense, he (Mr. Hoskold) was pleased to make an initiatory movement.

In taking a retrospective view of the labour of some few of the old English pioneers in science and inventions, upon whose achievements in the advancement of the sciences, engineering and surveying arts, the world had so much to depend, he (Mr. Hoskold) desired it to be understood that he was far from being prejudiced, and had no desire or object to detract from the merits of foreigners; but, at the same time, he believed that it would not be out of place to show in a legitimate manner that the British nation had been foremost in introducing refined inventions and improvements in surveying-instruments and in devising means for more exact work and progress in the art of surveying. And, although this might appear somewhat anomalous, still, in order to do it in an effective manner and make a fair comparison, it had been necessary to refer to both ancient records and more recent documents.

The tablets, or tile-library, discovered by Layard and others, and now deposited in the British Museum, London, afford abundant evidence, of a positive nature, that the "estates near to the rivers and canals, and round about the cities of southern Babylon, were systematically surveyed some 2,400 years B.C." Consequently, it is to be inferred that divided circular astrolabes were not only used in astronomical observations, but must have been applied to land-surveying, and, probably, also, to mine-surveying, and that, at intervals, during a long period of time, the art was forgotten, neglected, or hidden, and revived from time to time, until it made its appearance in Europe.

It is not, therefore, surprising to find that the planisphere,

1550 (Fig. 10),* the Digges theodolitus, 1571,† the Dutch circle with six plain sights, 1620-1625,‡ the French wooden circle, 1692,§ and others which he could mention, are all of the same type-class.

No doubt the Digges theodolitus led to the construction of his topographical instrument with vertical semi-circle and plain sights,‖ and it was doubtless the original type from which others were afterwards constructed with improvements, and represented in Britain to-day by the plain or cradle-theodolite. It would be difficult to define the date of each successive improvement, and, consequently, there is a gap in the record from the time of Thomas Digges, 1571, to that of the grand old firm of the Sissons, whose curious theodolite, with telescope, was introduced sometime prior to 1723. However, he (Mr. Hoskold) believed that the intermediate period, referred to above, was represented by the instrument illustrated by Fig. 1, an example of which is still preserved in the Conservatoire National des Arts et Métiers in Paris, and is reported by the authorities of that establishment to be of English

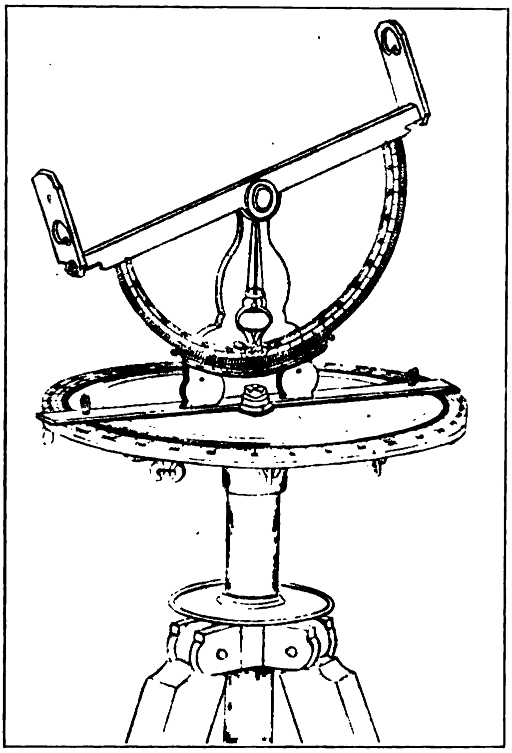


Fig. 1. – English Theodolite, 1632 to 1635.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 584.

† *Ibid.*, 1900, vol. xix., page 182.

‡ *Recherches sur les Instruments*, etc., by Col. A. Laussedat, Paris, page 67.

§ *Ibid.*, page 84.

‖ *Trans. Inst. M.E.*, 1902, vol. xxiii., page 591.

construction. A vernier is attached to the semi-circle of that instrument, and it has plain sights; but the name of the maker is not known. The vernier, however, affords evidence that it could not have been constructed before 1631; but it is probable that an approximate date for the construction of this instrument would be about 1632-1635. The original theodolite of Sisson had been illustrated and described in his (Mr. Hoskold's) third American paper,* and the description was now repeated by Mr. Scott.† This instrument was introduced some time prior to 1723. Afterwards, Sisson greatly improved it, and in the hands of successive makers it assumed the form now known as the English cradle-theodolite. Other instruments of a superior type will be referred to in this discussion.

When referring to telescopes and telescopic sights, that is, placing lines in the focus, Mr. B. S. Lyman, of Philadelphia, in his well-digested paper, or discussion of Mr. Scott's paper on "The Evolution of Mine-surveying Instruments, ‡ stated that "young Gascoigne . . . . was the leader, and, already by 1640, he used for the purpose a hair or thread at the focus. It was even claimed in 1675 that he [Gascoigne] had been the first to use a telescope of two convex lenses. At any rate, he was evidently the first to use telescopic-sights."§ He (Mr. Hoskold) also proved in his second American paper,‖ and in his reply to the discussion upon his "Notes upon Ancient and Modern Surveying, and Surveying-instruments," etc., that Gascoigne was the first to invent and apply an instrument for finding distances probably before, or at least, "between 1638 and 1643;"¶ and referring to the same subject, Mr. Lyman stated that "twenty years later it was re-invented upon the Continent."**

Whether the original form of telescope was discovered first, as had frequently been alleged, by Roger Bacon, 1290; Porta, 1561; Digges prior to 1570; the Dutch in 1608; or Galileo in

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., page 716.

† *Trans. Inst. M.E.*, 1902, vol. xxiii., page 593.

‡ *Transactions of the American Institute of Mining Engineers*, 1898, vol. xxviii., page 679.

§ *Ibid.*, 1900, vol. xxxi., page 79. ‖ *Ibid.*, 1900, vol. xxxi., page 25.

¶ *Trans. Inst. M.E.*, 1901, vol. xxi., page 411.

** *Transactions of the American Institute of Mining Engineers*, 1900, vol. xxxi., page 78.

1609, was not material to the points to be deduced from this discussion, for the reason that Hall, an Englishman, in 1733, and Dolland, prior to or about 1758, were the persons who originally invented, constructed and practically applied achromatic lenses to the telescope, and thus perfected and brought it to a more fit condition to be attached to angular measuring-instruments.

Without doubt, the climax in invention, at that period, calculated to perfect geodetic and other surveying instruments, was arrived at by the celebrated Ramsden, when he completed his first circular dividing-engine about 1773 or 1774, without the use of which the other prior inventions in telescopes would have left astronomical and surveying instruments in the same condition in which they were, as regards the method of dividing the circle, before Ramsden's invention. Ramsden constructed at least four dividing-engines, one of which was received at the Conservatoire des Arts et Métiers, Paris, in 1795. A second is preserved in the South Kensington Museum, London, and two others of Ramsden's make are still in excellent condition, and constantly used to divide circles by Mr. Parsons, a London divider to the trade. One of the last is reported to be "one of the finest pieces of mechanism that the world ever saw." The circle of the great 36 inches geodetic theodolite of Ramsden, 1780 to 1783, illustrated in Fig. 5 of his (Mr. Hoskold's) paper,* was divided by his engine, and so perfectly was the work done that the probable error of a single observation of a fine object with this instrument would not amount to 0·2 second of arc. Ramsden was the first to illuminate the cross-hairs in the telescope of his transit-instrument by perforating the axis. He was also the first mathematical artist to apply micrometrical readings to the divided circle of his great theodolite; and Quekett† ascribes to Ramsden the practical introduction of spider-lines in micrometers; but, according to the opinion of some persons, Troughton first placed such lines in the focus of telescopes. Fontana, 1755, and Rittenhouse, probably about 1785, have also been mentioned in connection with this invention. Among many claimants, with interested parties to back them up, it was difficult to determine who was the first to devise and introduce certain inventions.

This remark applies to the microscope, and it is stated on no

* *Trans. Inst. M.E.*, 1900, vol. xix., page 188.

† *Encyclopedia Britannica*, 1883, vol. xvi., page 243.

less an authority than Mr. Lyman that "Huygens' investigations made it probable that it [the compound microscope] was first invented by Drebel, a Dutchman, in London, about 1620."*

Since Ramsden published an account of his dividing-engine in 1777, foreign makers have also constructed dividing-engines upon the same principles. The one in the Conservatoire des Arts et Métiers, Paris, would, doubtless, have afforded the details for the construction of others. Previous to 1843, the late Mr. William Simms, of the firm of Messrs. Troughton & Simms, constructed a dividing-engine, and Mr. William F. Stanley stated to him (Mr. Hoskold) that it is believed to be the best in London.

The circles of the great 36 inches geodetic theodolite constructed by Messrs. Troughton & Simms for the Indian Trigonometrical Survey, and illustrated by Fig. 6,† were divided by the Simms dividing-engine, and after a rigorous and delicate examination of the divisions of the circles had been made, the late Col. Strange (the late technical examiner of Indian geodetic instruments) could not discover 1 second of arc of difference between the divisions. The original dividing-engine is still in constant use in the establishment of Messrs. Troughton & Simms.

A careful examination of his (Mr. Hoskold's) paper‡ will show that although Snellius, 1615, and Picard, about 1669, commenced surveying, still, it does not appear that the great English pioneering surveyors, Norwood, 1635, and General Roy, 1747 to 1755, derived any instructive principle from them, and if Newton had not discovered his ever-memorable principles, whence he deduced the true figure of the earth, the French would not have been incited to the efforts which they afterwards exhibited. It is scarcely necessary to mention the names of succeeding English surveyors, such as Mudge, Dalby, Colby, Kater, Lambton, Everest, Walker and others, in order to prove that the British nation possessed original thinkers capable of carrying into effect the application of scientific principles upon which depended the good results of the practical work that they all carried out, without deriving anything vital from the scientists of neighbouring nations.

Coming now to the discussion of the great aid that surveyors

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., page 74.

† *Trans. Inst. M.E.*, 1900, vol. xix., page 197.

‡ *Ibid.*, 1900, vol. xix., page 184.

of all classes and nations have received in the reduction of their practical operations with the greatest ease, accuracy and facility, we have only to refer to the great mathematical ingenuity displayed by Baron Napier, who, in 1614, published his remarkable invention of logarithms. His book contains a description of the nature of logarithms, and tables of natural sines and their logarithms to every minute of the quadrant and to seven places of decimals. Briggs, the Savillian professor of geometry at Oxford, followed, in 1616, with a table of logarithms. Gunter, the colleague of Briggs, published, in 1620, the first calculation of "Briggian logarithms of trigonometrical functions." This book was called *Canon Triangulorum*, and it contained logarithmic sines and tangents for every minute of the quadrant to seven places of decimals. The great work left by Briggs, afterwards published, in 1638, under the title of *Trigonometria Britannica*, was the climax of his achievements, and contained tables of logarithmic sines to 14 places of decimals, and tangents to 10 places of decimals, as also tables of natural sines, tangents and secants. The productions indicated and initiated by Napier, and continued by Briggs, placed the British nation in an independent position for all time, so far as facile means for calculations were concerned, in the benefit of which foreigners partook in a high degree. Whether Napier derived any notions from the work of Regiomontanus (1436 to 1476) in the same manner as Mr. Scott says that Reinhold had done, is impossible to decide; however, it may have been possible. That additions and improvements in the method of arranging such tables have followed is certain; but the principles laid down by Napier, and continued by Briggs upon a different basis, have not been nor ever will be superseded. The natural sines, etc., referred to above, formed of themselves co-ordinates. The logarithms and logarithmic sines also afforded facile and direct means for the same object, and if the surveyors of that period, and for some time afterwards, did not apply those principles, it was not for the want of means ready at hand.

Mr. Scott observed that Reinhold "explains the co-ordinate system of plotting, and actually introduced a lucid treatment of trigonometrical calculation after Regiomontanus (1436 to 1476)"* but it is not stated that Reinhold prepared tables to

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 576.

facilitate the use of the co-ordinate system, without which a mere "explanation" would possess less value. It is not probable that the work of Reinhold was known in England, at least to any extent, up to the time when Budge published his last edition in 1866; at any rate, it is not referred to in any work upon surveying, in English, known to him (Mr. Hoskold), neither has he seen any English book upon mine-surveying earlier than Houghton, 1681, and probably such does not exist. Nevertheless, there is no reason for supposing that the plan of surveying indicated by that author may not have existed for two or three centuries earlier. If, however, we take the moderate estimate of 250 years, that would take us back to 1431, leaving a period of, at least, 251 years to invent means of applying the magnetic needle to mine-surveying, or from the time of Necham, 1170 and 1180, who, as he (Mr. Hoskold) had previously stated, if not the first inventor, introducer or user of the magnetic needle, was the first to write about it in England.* If there is nothing certain about the estimate of time that we have made above, we shall, at least, be within the limits of probability.

The Romans worked the tin-mines of Cornwall, the lead-mines of Derbyshire and the iron-mines of Birmingham (at intervals) down to 300 A.D.† According to the State papers, Henry II. granted permission to work iron-mines and to erect forges to reduce the mineral to metal, somewhere between 1154 and 1160, before Necham wrote. There might, therefore, have existed a need for mine-surveying, at any rate, upon a small scale, no matter how rudely conducted; and, as he (Mr. Hoskold) had previously stated, such operations may have been carried on by means of a small plane-table, or three-legged stool, a chalked string or cord, and a measure, until the introduction of the magnetic needle. He (Mr. Hoskold) had not discovered any record proving that the mines of the Hartz were much explored earlier than about 1200. Earlier records may, however, be accessible to others. It is interesting to note that it is believed that the first book published in Germany upon mining appeared in 1504 to 1505, with other editions in 1515 to 1518.

The Director of the Mining Academy, at Freiberg, courteously sent to the writer a photograph of the title-page of the latter edition of the work referred to, as also of two old instruments

* *Trans. Inst. M.E.*, 1900, vol. xix., page 181.

† *Cyclopedia of Classified Dates*, 1900, page 840.

employed in mine-surveying at the period mentioned. A description of these rarities, probably the only examples known, was published in his (Mr. Hoskold's) second and third American papers,* and Dr. Raymond was good enough to translate the title of the book from German into English. It is as follows:—"A well arranged and useful little book: How mines should be sought and found, of all kinds of metal, with the figures suitably indicated, according to the circumstances of the country-rock, with appended mining terms, very serviceable to working miners." The old instruments referred to, are represented by Figs. 2 and 3,

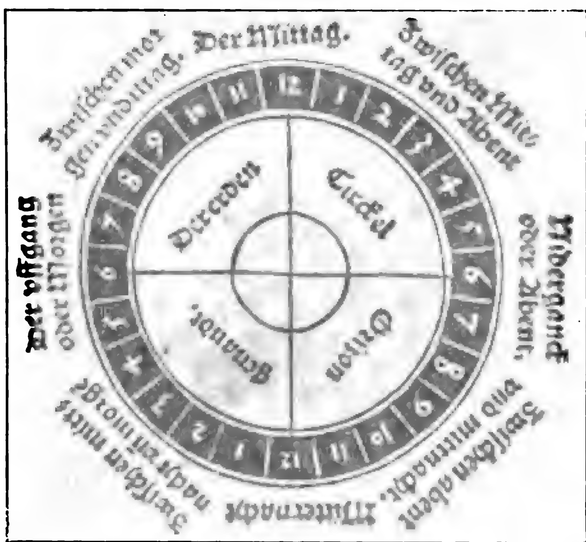


Fig. 2.—Mine-surveying Compass, 1504 to 1515.

the first of which seems to be the oldest form. The exterior circles, engraved upon it, are divided by lines representing the four cardinal points, and the first, or meridian-line, indicated mid-day to mid-night, and, consequently, the right-hand half of the circle is divided from 1 to 12 hours, and the left-hand of the circle, or from mid-night to mid-day, is also divided from 1 to 12 hours. It would seem that Fig. 3 is an improved variation of Fig. 2: it has a double set of circles and, also, a double set of figures on the same plan as Fig. 2. A magnetic needle was

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., pages 25 and 716.

also mounted at the centre of the instrument. Without doubt, when in use, the needle must have been pointed to 12 hours as a zero-point, and then the direction of any underground road must have been indicated by stretching a string or cord over the instrument and along the road or excavation, the division then cut upon the instrument by the cord being noted. Any bearing or intermediate direction between the hours must have been estimated. The surveying-instruments represented by Figs. 2 and 3 are older than any of the instruments described by Mr. Scott, in his American and British papers upon the subject.

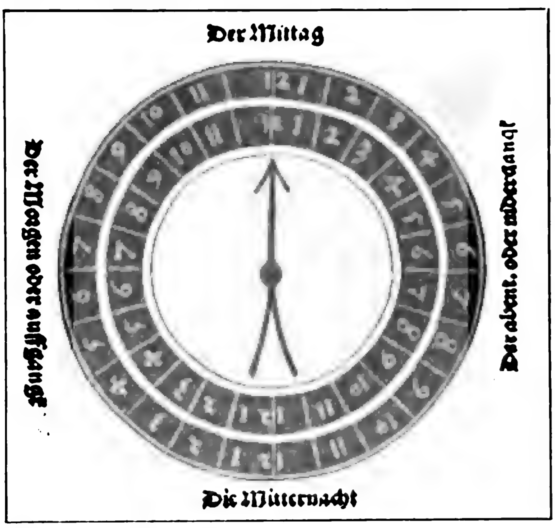


FIG. 3.—MINE-SURVEYING COMPASS, 1515 TO 1518.

The paucity of books on mining and mine-surveying in England prior to the time when Houghton wrote in 1681, or in the olden times, is a very remarkable circumstance; but considering that book-learning and the art of writing books were chiefly confined to the higher dignitaries of the Church, and in Latin, it is not so surprising that those of that period, occupied in mining and mine-surveying, were so little adapted to convey their ideas and practice in writing. Neither was the German language common in England from the time of Houghton to that of Fenwick and Budge. It is not, therefore, probable that German scientific literature had any influence upon English mining men in the sense of providing means of instructing them

in mathematics and the art of land and mine-surveying. Setting aside, for the sake of argument, Reinhold's early work, and the chapter on mine-surveying in Agricola (1556) as foreign productions, Houghton would appear to be the first English writer upon the subject of mine-surveying, in 1681, some five years before Voigtel wrote in 1686; but the latter work is of a distinct class from the former. From 1681 onwards, many works upon surveying appeared in England, some of which contained tables of logarithms and sines, for co-ordinate purposes.

Special works dedicated exclusively to mine-surveying were very limited, compared with the importance of the subject; and it is probable that, down to a comparatively modern period, practical surveyors may have considered that some of the principles, laid down in land-surveying books, were sufficient and could be applied to underground surveying. Mr. Scott's appreciation of Fenwick, 1804, and Budge, 1825, is correct, and it is pleasing that he has accorded to them the merit which they so much deserve. How absurd is the idea that Budge's book is considered by only a single individual as "dealing only with the mines of Cornwall!" He (Mr. Hoskold) had always maintained that, as a system of magnetic or dial-surveying, Fenwick's book would never be superseded; besides he was the first to indicate the plan upon which the present English system of theodolite-surveying in mines is based. Baker, the civil engineer, had so great an estimation of the value of Fenwick's *Mine-surveying*, that he published a new edition of it in 1877.

Since he (Mr. Hoskold) published his practical system of mine-surveying in 1863, various notices upon mine-surveying have appeared. An excellent chapter on this subject will be found in Mr. Caleb Pamely's *Colliery-managers' Handbook*, 1898, and of the few works exclusively devoted to it a recently-published book is highly to be recommended.*

In his American and English papers, he (Mr. Hoskold) had already expressed his opinion upon the new instrument introduced by Mr. Scott; but he did not wish to occupy the invidious position of comparing his new civil and mining engineers' transit-theodolite with that of Mr. Scott, because he believed that it was far preferable to allow each instrument to rest upon its own merits, and to be appreciated and judged, after use, by practical men.

* *A Practical Treatise on Mine-surveying*, by Prof. Arnold Lupton, Longmans and Company, London, 1902.

There was ample evidence that all instruments in England, which could be applied to mine-surveying, have been, more or less, changed in form to suit various ideas and conditions, from the old plain magnetic dial in Stones' (Bion's), 1723, to the present time, and, in some instruments, such changes have involved important inventions. This remark may be claimed to apply to the very popular instrument called the Hedley dial-circumferentor, in its various forms as presented by different makers, as also, to other instruments, but such changes can only be summed up as improved means to facilitate and obtain a particular end, that is, to offer more or less advantage in accuracy, speed and ease in observing magnetic bearings, and horizontal and vertical angles; but this does not alter the scientific base of a principle upon which a practical system of mine-surveying rests. The how, and in what manner, mine-surveys should be best conducted, depends upon the application of unalterable mathematical principles, that is, the principle of doing a given kind of work is one thing, but the instruments by which it is to be effected is quite a different thing. It cannot be doubted that the instruments produced in modern times for all classes of surveying operations, by the well-known and long-established firms of Messrs. Troughton & Simms, Elliot Brothers, Cary, Stanley, Stewart, Casella, Archbutt and others in London; Messrs. John Davis & Son of Derby, and Messrs. Cook of York, etc., cannot be excelled by a similar class of production in foreign countries, and, for these reasons, foreign surveying-instruments are not necessary or employed in England, India, or the British Colonies. Besides, British instruments are preferred in the Argentine and other South American republics. Without prejudice, or entertaining the slightest intention to affect or injure the susceptibilities of those who are meritorious and have claims to the greatest considerations, he (Mr. Hoskold) believes that this notice contains confirmatory evidence, of an absolute character, proving the hard-earned, well-merited and long-established credit of the British people in reference to the particular subjects which have been brought forward and discussed.

Under the conditions presented, therefore, it must be considered to be an unhappy circumstance and "sincerely to be regretted," that Mr. Bennett H. Brough had entered upon the unusual course of a rejoinder* to his (Mr. Hoskold's) reply to

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 620.

Mr. Brough's criticisms upon the paper "Notes Upon Ancient and Modern Surveying and Surveying-instruments," etc. This criticism, occasioned by Mr. Scott's paper and the remarks thereon, exhibits, in the clearest manner, that his (Mr. Hoskold's) opinion, formerly expressed in the passage alluded to, and so distasteful to Mr. Brough, is not only based upon and justified by the circumstances and antecedents of the case; but upon experience and close observation extending over a period of more than half a century. It is quite possible that a few of those who have been devoted merely to scholastic pursuits may have acquired, and enriched themselves by, the knowledge circulated in foreign countries; but he (Mr. Hoskold) was thoroughly convinced that Englishmen, as a rule, had not received so much valuable assistance and instruction in mathematics, other sciences, inventions and construction of instruments, and in the art of land and mine-surveying as Mr. Brough, and a few others of his way of thinking, would lead us to believe.

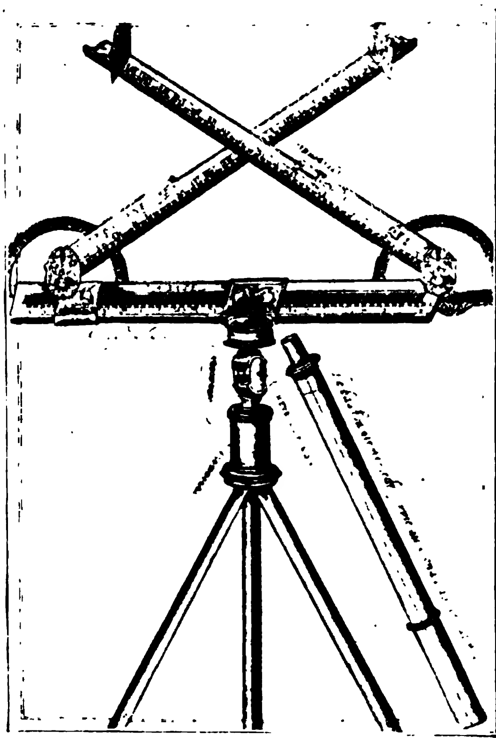


FIG. 4.—THE DAUFRIE TRIGOMÈTRE, 1597.

In an excellent work previously noted,* an old surveying-instrument is illustrated and called trigomètre, originally existing in a work of Daufrie, 1597, and reproduced in Fig. 4. Colonel Laussédat is of opinion that Daufrie invented the instru-

* *Recherches sur les Instruments*, etc., by Col. A. Laussédat, Paris, 1898, page 79.

ment, and it appears that it was intended to be employed for finding distances.

When re-arranging his library, some time ago, he (Mr. Hoskold) came upon some old Italian scientific literature, and an examina-

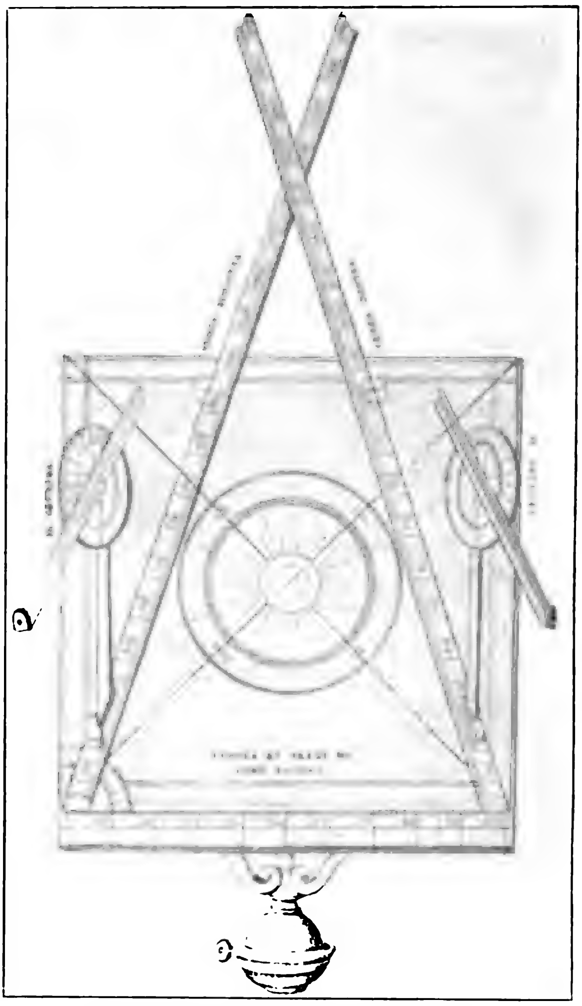


FIG. 5.—THE HOLOMETRO, PRIOR TO 1564.

tion of one of the books published by Zilleti, at Venice, in 1564, brought to light a very old and curious instrument, also used for measuring distances. It is represented by Fig. 5, and is termed *holometro.* Zilleti says, " Having come into my hands, the present

work is translated into our language (Italian) from the French, by a gentleman of this city for amusement, and as it appears to me to be useful, I desire to publish it." From the description given, it is clear that the original work by Fullone was written in French, and considering that he was a valet of the King of France, he must have been a favourite of Catherine de' Medici. It is prob-

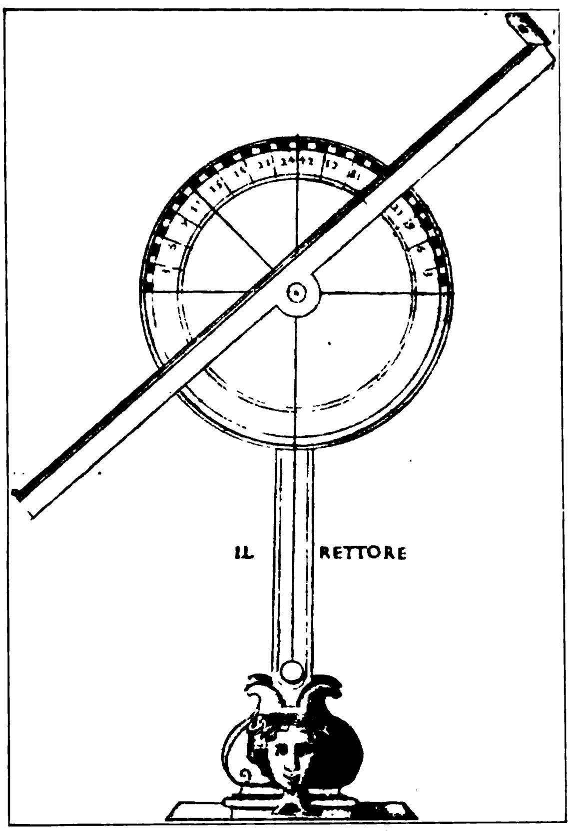


FIG. 6.—THE STAND AND VERTICAL CIRCLE OF THE HOLOMETRO, PRIOR TO 1564.

able that he invented his holometro and produced his work describing its use somewhere between 1540 and 1564. This instrument is at least 33 years older than that of Daufrie, and probably it may have been the original form from which Daufrie's instrument was constructed. Fig. 5 represents the holometro, which consists of a square base of metal, or of wood, with a magnetic compass mounted at its centre. One of the sides of the square, or

the lowest in the diagram, was divided into 100 equal parts, as seen in the engraved base-scale, and, upon each of the ends of the base, a long divided bar or rule was mounted, upon a pin or axis. Each of the extended rules or bars, revolving on an axis, was divided into 190 equal parts. At the point represented by the division of 100 upon each rule, a joint was formed, so that the rules could be bent to fit the sides of the square or instrument for convenience of packing and carriage. Fig. 6 represents the leg or stand, at the upper part of which a divided circle was mounted upon an axis. A long bar with plain sights was also mounted upon the same axis, and revolved vertically round the circle. The lower end, of the leg or stand, had a base in the form of a dovetail, and when the holometro was in use, this part was inserted into a corresponding dovetail groove made between the thirteenth and twenty-eighth division of the long rules or bars; consequently there were two vertical stands, or legs, with circles and plain sights, one of which was placed on each of the horizontal bars when the instrument was in use. When the holometro was placed upon its common stand for use, it was levelled by means of a plumb-line suspended from the centre of each of the vertical circles. The zeros of the vertical circles were also determined in the same manner. Fig. 6 indicates that only the upper half of the circle was divided; but the Italian text describes the circle as being divided round the whole circumference.

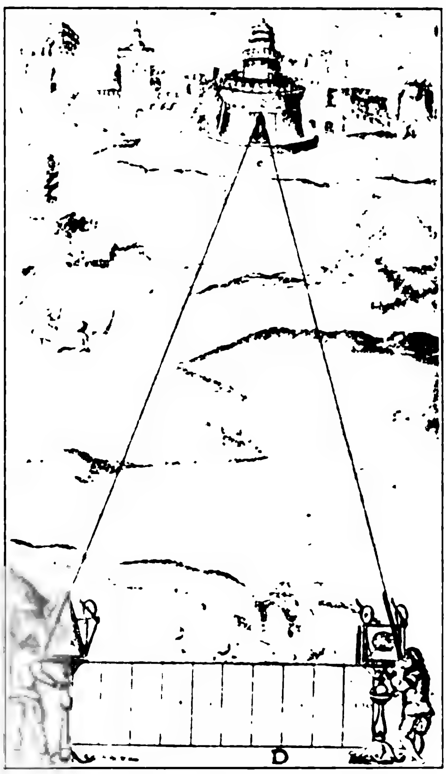


Fig. 7.—Method of Using the Holometro, prior to 1564.

It appears from the Italian description that, when a distance had to be determined, the operation was carried out as shewn in Fig. 7. A base-line of 100 units was measured on the ground, and the instrument set up at the first or right-hand station, and the line forming the divided side of the instrument was directed so as to coincide with the second, or left-hand station. Then a sight was taken by means of the plain revolving sights of the right-hand bar, which moved with it, to the extreme point at C. The magnetic bearing was then read, and the right-hand bar was allowed to remain in its position. The instrument was then removed to the second or left-hand station and the needle of the compass made to point to the same bearing as that noted at the first station, which operation would bring the line forming the divided base of the instrument in the direction of the first station. The left-hand plain revolving sights to the second vertical circle, were then directed to the point C, and the divisions cut by the crossing point of the two divided bars indicated the length of the two lines observed. When the distance was so great that after sights had been taken to the distant object, the divided bars would not cross each other; the left-hand bar with its divided quadrant was slidden along the metallic base in order to diminish the distance from 0 to 100, until the two bars would cross each other; the plain sights of each being directed at the same time to the distant object. The distance was then found by the rules of proportion. Great interest is attached to this instrument, for the reason that the vertical circle and plain sights, mounted upon a leg or stand, as shewn in Fig. 6, afford evidence that the present principle of mounting surveying transit-theodolite circles is more than 340 years old. The only difference is that the old vertical circle of 1564, exhibited in Fig. 6, was suspended and supported upon an axis at one point, instead of at two points as in present practice; but there is no doubt that the latter was derived from the former.

The Italians also practised other curious modes of finding distances by means of geometric squares, and other classes of instruments at an early date* as the footnote shows.

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* (1) *Libro del Misura con la Vista*, by Silvio Delli Vicentino, Venetia, 1566; and (2) *Monicometro Instrumento da Misurar con la Vista*, by Francesco Pifferi, Siene, 1595.

DISCUSSION OF MR. H. LIPSON HANCOCK'S PAPER ON THE "MINING AND TREATMENT OF COPPER-ORE," ETC.*

Mr. H. Lipson Hancock (Moonta Mines, South Australia) wrote that following mechanical concentration and smelting, the wet treatment of vein-stuff containing sulphide copper-ores (especially those associated with iron-pyrites, and these were probably more common than those that were free from the latter mineral) was essentially required, and present-day experience was proving that this style of treatment would be more widely adopted in the future than it had been in the past. It had gradually grown in connection with the operation of the Wallaroo and Moonta mines, and he hoped at an early date to attain an extraction in this department of over 2,000 tons per year, providing an ample supply of acid is available. Of course, this output would be obtained from treating a large quantity of crushed vein-stuff, which had accumulated during a number of years; nevertheless it indicated the importance attaching to the process. There was no doubt that this means of extraction, in which the assistance of sulphuric acid played an important part, would be still further improved.

He (Mr. H. Lipson Hancock) might repeat that the tailings at the Moonta mines are chiefly felsite-porphyry, with a small percentage of copper-pyrites and a little bornite. The assay for copper in recent years was about 0·7 or 0·8 per cent., although the average of the full heaps under lixiviation might be set down at 0·9 per cent. There is only a very small percentage of iron-pyrites in the material of the Moonta mines under treatment, so that it causes a dearth of iron in the liquors. In order, therefore, to facilitate the leaching operations, it will be necessary shortly to use a small percentage of sulphuric acid; this will enable the liquors to attack the proto-salts of copper as they are formed, and lead to higher extraction. New tailings from the concentrating plants, after dumping, are periodically soused for some weeks, and then allow to rest for 3 or 4 months, according to circumstances. They are then drenched again; and, after a further short rest, they are generally in a sufficiently oxidized state for leaching, as indicated above.

The precipitate is washed against a stream of fresh water, and

* *Trans. Inst. M.E.* 1901, vol. xxii., page 461.

divided into three classes, the coarser and heavier being separated as the best. The first and second classes are melted in a reverberatory-furnace, with other coarse copper from the concentrating ores. There is only a small percentage of the third-class precipitate, and this has to pass through two furnaces in the smelting. There was, he might say, a freedom from impurities in the material, and good copper known as the Wallaroo brand resulted therefrom.

DISCUSSION OF MR. J. J. MUIR'S PAPER ON THE "TREATMENT OF LOW-GRADE COPPER-ORES IN AUSTRALIA."*

Mr. H. Lipson Hancock (Moonta Mines, South Australia) wrote that there is no doubt that sulphuric acid is useful in connection with the wet treatment of sulphide ores of copper, especially when oxidation has more or less set in. This may be the result of natural weathering, but it is generally a slow operation. If, however, the ore be properly dumped and soused periodically with liquors containing salts of iron, and is allowed to rest and dry for some time, oxidation is very much promoted. Sulphuric acid applied at this stage is a powerful solvent, and its use has led to very satisfactory results.

DISCUSSION OF MR. F. J. NORMAN'S PAPER ON "BORING IN JAPAN."†

Mr. F. J. Norman (Calcutta) pointed out the following errata in his paper:—On page 685, line 6 should read "depths of 300, 480 and 720 feet below sea-level, and the depths increase the farther one goes inland." On page 690, line 8 should read "depth of from 5 to 8 feet," etc; and line 13, "bottomless tub or box," etc. Page 691, line 17 should read "(*Zelkowa acuminata*)."

Mr. William Charlton read the following paper on the "Use of Ratchet and other Hand-machine Drills in the Cleveland Mines":—

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 517.
† *Ibid.*, 1902, vol. xxiii., page 685.

USE OF RATCHET AND OTHER HAND-MACHINE DRILLS IN THE CLEVELAND MINES.

By WILLIAM CHARLTON, Assoc.R.S.M.

Some twenty years ago, almost the whole of the Cleveland ironstone was won by the chisel-pointed hand-drill, with a swelled end to add weight to the blow, and well known to all interested in mining as the "jumper-drill."

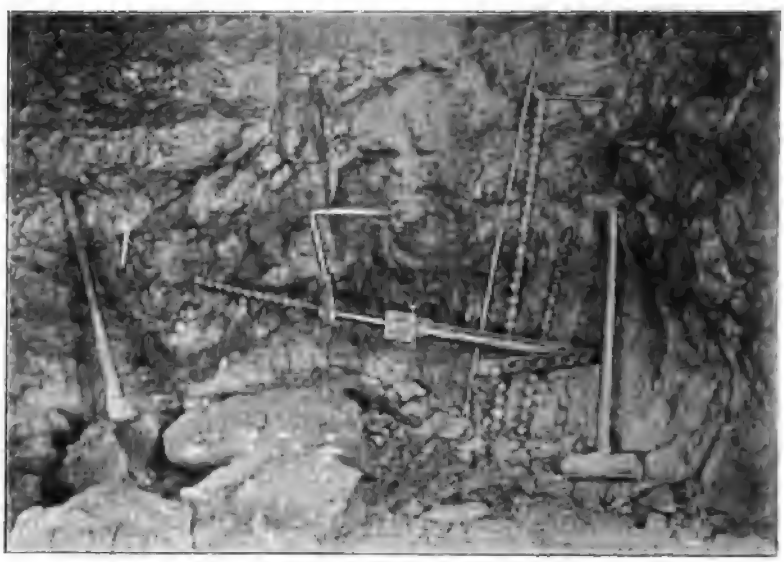


FIG. 8.—HARDY RATCHET DRILLING-MACHINE.

So established had this mode of drilling become that the old practical miner of that time naturally considered it necessary for working the Cleveland stone that the holes should have the triangular shape △, and that it was only by his skill in drilling, with the jumper-drill, a hole with a "flat-back" or "flat-front," "flat-top," or "flat-bottom," that the stone could be successfully mined.

Experiments, however, had been made with rotary drills, which showed conclusively that a round hole could work the stone; and the millions of holes which have since been drilled by the compressed-air and electric drills, so successfully introduced by Mr. William Walker and Mr. A. L. Steavenson, are more than ample proof of their suitability.

FIG. 9.—PENDULUM DRILLING-MACHINE.

Since 1880, mining by power-machines has made great progress and at the present time about one-third of the Cleveland ironstone is won by such machinery.

Until 1888, very little use had been made of the hand-machine drills. The late Mr. George Lee had tried some at the Liverton mines, and the late Mr. T. Allison, of Guisborough, had introduced a few ratchet-machines into the Belmont and Spawood mines of the Weardale Iron & Coal Company, Limited.

In 1884, owing to depression in the iron-trade, the Slapewath mines of Sir B. Samuelson & Co. were closed. It being absolutely necessary that steps should be taken to reduce the cost of winning the ironstone, on restarting the mines in 1886, a thorough and exhaustive trial of the ratchet-machine was instituted. The first machines were of crude construction, being fitted with loose

FIG. 10.—GRAY-TARBIT ROTARY DRILLING-MACHINE.

brasses in the barrel and thick-edged drills; and, when drilling the hole, the machine was set against a prop fixed between the roof and the floor.

It was soon found that a great drawback to the use of the machine was the time spent in setting these props or stands, a considerable portion of the time saved in drilling the hole being spent in the preliminary setting of the props and in changing the drills. In many instances, the stone thrown down by the

previous shot would be lying where the prop should stand; and in other instances, owing to projections of the side of the working-place, the prop could not be set near enough to the side to obtain the right direction of the hole. It became necessary, therefore, to supplement the prop with a cross-bar of iron between it and the side of the place, the end of the machine resting against this bar. Old permanent-way fish-plates were found to be suitable for this purpose. For convenience, they were pointed at one end to make the bar fit better against the stone, the other end being fastened by a nail to the prop.

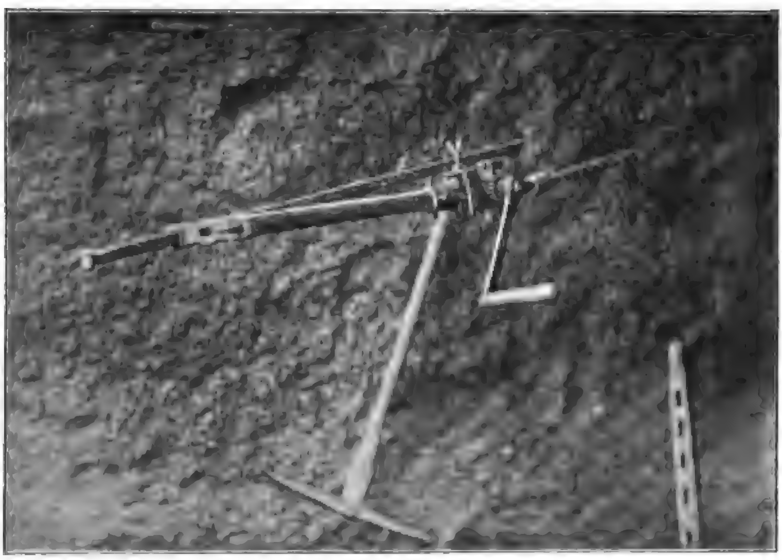


FIG. 11.—GRAY-TARBIT ROTARY DRILLING-MACHINE.

After a time, this pointed end was driven into a recess made in the stone, and it was found to fasten itself so well that when a stronger bar of iron was pointed with a chisel-end and driven into a hole made about $1\frac{1}{2}$ inches deep, by a pick, it was sufficiently firm to stand the thrust of the machine without the aid of a prop to support the other end.

This discovery, at once, very materially increased the facilities of working, and may be said to have brought about the success which has attended the use of this mode of drilling in the Cleveland mines. It rendered unnecessary the props or stands which

were hitherto used, and made it possible to fix the machines so that the holes were drilled in the very best position for the advantageous blasting of the stone.

Figs. 1 and 2 (Plate XV.) show the pointed bar, *a*, of iron driven into the side of the place, and the ratchet-machine set for drilling; *b* is the barrel of the drill; *c*, the nut-collar; *d*, the screw-spindle; *e*, the ratchet; and, *f*, the drill-end. The bracket or bar is chisel-pointed at *g*, and is formed with a number of holes, or countersunk recesses, *h*, for receiving the barrel-end, *i*, of the drill.

FIG. 12.--HALL ROTARY DRILLING-MACHINE.

A remarkable development of the means employed to take advantage of the property possessed by the stone of holding fast the bar of iron driven into it is shown in Figs. 3, 4 and 5 (Plate XV.), a modification designed for use in starting or turning-away places at right angles to the winning-place. The long bar, *a*, is chisel-pointed at the end, *g*, *j*, is a short bar with holes or countersunk recesses, *h*, and with a socket, *k*, capable of sliding on the bar, *a*, to any convenient position. Other modifications will be seen in the illustrations or photographs of the machines in working positions.

While progress was being made in the manner of setting the machines, improvements in the machine itself were not neglected. Clasps were substituted for the loose brasses in the machine shown in Fig. 1, and some time afterwards these were discarded for the improved ratchet-machines of the Hardy Patent Pick Company with the Stayner split-nut (Fig. 6, Plate XV.) for the quick withdrawal of the drills (Fig. 8).

A lighter and fish-bellied  section of drill-steel was procured, which proved to be a great improvement; and, combined with these, it was found that a square-topped screw with

Fig. 13.—Blackett-Hutton Rotary Drilling-machine.

4 threads to the inch, instead of a Whitworth screw with 7 threads to the inch, whilst increasing the speed of the drilling by 75 per cent., scarcely, if at all, increased the labour.

To obtain the benefit of the weight of the handle and the advantage of the pulling-down stroke when the drill is advancing, which is the case with the machine in the position shown in Fig. 1 (Plate XV.), machines with left-handed screws and drills were obtained for use when the holes were to be drilled on the other side of the working-place (Fig. 8). Each pair of workmen was supplied with two machines, thus enabling them to use the machine best suited to the situation.

Many other devices of machine have been tried, such as the pendulum-machine (Fig. 9), which by an arrangement of bevel-wheels gave a cutting stroke at each stroke of the handle; the double-handled ratchet-drill (Fig. 7, Plate XV.), and others.

Passing over these, a great advancement was made by the introduction of hand rotary machines for drilling the softer stone; and Messrs. Gray & Tarbitt's machine was introduced at the South Skelton mines (Figs. 10 and 11).

FIG. 14.—HARDY ROTARY DRILLING-MACHINE.

Mr. William Hall's machine is in use at Messrs. Pease & Partners', Skinningrove and Upleatham mines (Fig. 12); and Mr. C. Heslop's machine, more suited to the harder stone, is used at their Lingdale mines. Mr. John Martin, a working miner, introduced a simple, but useful rotary machine at the Skelton mine. Messrs. Blackett, Hutton & Company, the Hardy Patent Pick Company and Messrs. John Livingston & Sons have a large number of their machines in use at several of the Cleveland mines (Figs. 13, 14 and 15).

Fig. 16 shews a miner using a jumper-drill.

Among those who have given so much thought and attention to the development of drilling by ratchet and hand rotary machines

in the Cleveland mines, the names of my assistants, Mr. James Thompson and Mr. William Brooks, deserve particularly to be mentioned.

The usual practice of Cleveland hand-mining is for two miners to work together as mates, one man drilling the holes, charging and firing the shots, while the other man breaks up and fills the stone into the tubs or wagons.

Many experimental trials have been made to ascertain the relative time occupied in drilling by the jumper-drill, the ratchet,

FIG. 15.—LIVINGSTONE ROTARY DRILLING-MACHINE.

and the hand rotary machine, and in some cases very remarkable results have been obtained. Not wishing to exaggerate the value of the ratchet or hand rotary machines, the writer is keeping well within the mark in stating that two holes can be drilled with these, to one with the jumper-drill; and that, under ordinary conditions, the output per shift of the pair of men can with ease be increased fully 20 per cent.

In addition to this advantage, the diminished amount of physical labour, required in working these machines, enables men to continue mining, who would have been compelled to abandon it, if restricted to the jumper-drill; and it also allows youths,

under the direction of their fathers or other men, to engage in mining at a comparatively early age.

Table I. shows the gradual increase in the use of ratchet and other hand-machine drills in the Cleveland mines, in percentage of the total output each year.

FIG. 16.—MINER USING A JUMPER-DRILL.

TABLE I.—PERCENTAGE OF THE OUTPUT OF THE CLEVELAND MINES, WROUGHT BY RATCHET AND OTHER HAND-MACHINE DRILLS.

Year.	Per Cent.	Year.	Per Cent.	Year.	Per Cent.	Year.	Per Cent.
1886	0·50*	1890	2·94	1894	10·23	1898	31·39
1887	1·53	1891	2·79	1895	12·82	1899	33·46
1888	2·05	1892	3·09	1896	21·86	1900	40·47
1889	2·93	1893	5·00†	1897	28·97	1901	39·55‡

* Commenced using ratchet-drills at the Slapewath mines.

† Introduced at other mines.

‡ Large temporary decrease at one mine, owing to depression in the iron-trade.

To illustrate Mr. W. Charlton's Paper on the "Use of Ratchet and other Hand-machine Drills" etc.

Fig. 2.

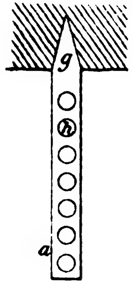


Fig. 1.

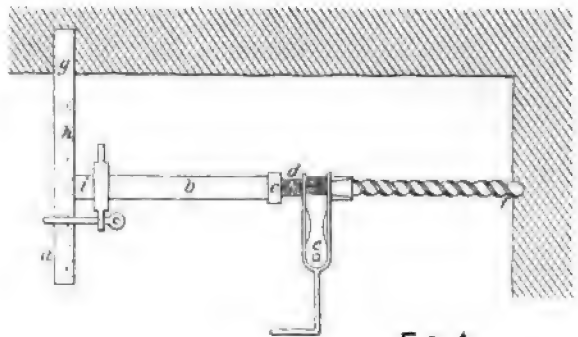


Fig. 4.

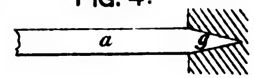


Fig. 5.

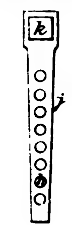
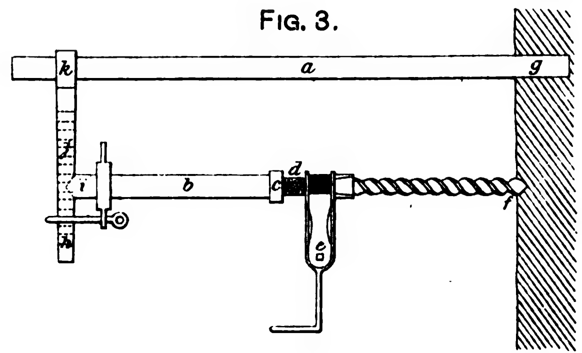


Fig. 3.



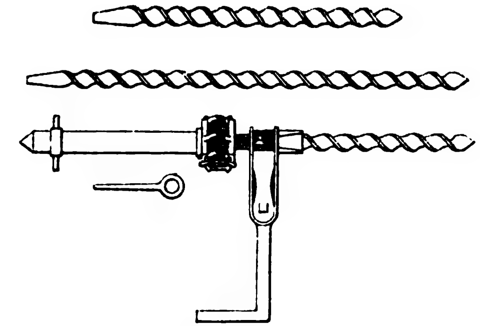


Fig. 6.—Hardy Ratchet-drill.

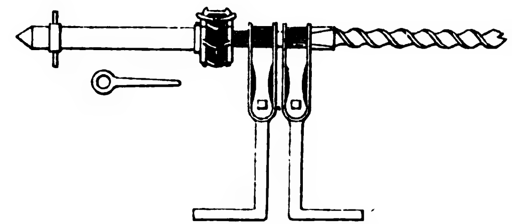


Fig. 7.—Hardy Double-handled Ratchet-drill.

Andw Reid & Compy Ltd Newcastle on Tyne.

Mr. A. L. STEAVENSON (Durham) said that good work appeared to have been done by the drills described by Mr. Charlton, but in his opinion there was nothing equal to an electrically-driven drill, which only required one skilled man to look after it, while unskilled men could do all the other work required in connection with taking down the ore. Electric-drills were also more economical in working than ratchet-drills—good as these latter were. Many of the members had, no doubt, seen electrically-driven drills in operation at the mines in Cleveland under his charge.

Mr. N. R. GRIFFITH (Wrexham) said that it might not be out of place for him to mention that he was driving a drift, in metals, about 2 miles long, and he was using rotary drills worked by compressed air. In hard rocks, percussive drills were used, and in shales and metals, rotary drills were used; and they changed from one system to the other, according to the nature of the strata. If rotary drills would not bore the stone, then they used percussive drills, the drills in all cases being driven by compressed air. A percussive drill did not appear to him to be a very scientific piece of machinery, because, from the nature of its action, it was knocking itself to pieces all the time that it was working. He had not had any experience with electrically-driven rotary drills, and they might possibly have a great future before them.

Mr. W. WALKER (H.M. Inspector of Mines) wrote that he had read Mr. Charlton's paper with much interest, as he well remembered the introduction of rotary drilling-machines, driven by compressed air, into the Cleveland district—at Stanghow ironstone-mines about 25 years ago. At that time, it was thought, and especially by the miners, that the circular hole would not produce such good results as the triangular one, but this prejudice was eventually overcome, and at the present time, as the author states, quite one-third of the Cleveland ironstone is got by the power-machines. For some years, even after the introduction of the rotary drilling-machine, the theory that percussive drills were best suited to the mining of Cleveland ironstone was held by many of the mine-managers, and the Eclipse and other percussive machines, driven by compressed air, were introduced into some of the mines. Eventually it was decided to try the

rotary drilling-machine, in the same mine and district as the percussive machine, for a period of three months, and the result proved so conclusively the superiority of the former, both as regards the number of holes drilled and the quantity of ironstone got per shift, that the use of power percussive drills was discontinued, and, at the present time, the whole of the power drilling-machines, whether driven by compressed air or electricity, are rotary machines drilling circular holes.

The methods adopted to dispense with the props, which were at first set between the roof and floor, for the ratchet-machines to be set against, are ingenious and simple, and allow of the shot-holes being drilled in the required position and direction; and, at the same time, one man can be drilling holes, while the other is filling away the stone brought down by previous shots.

One point is not mentioned by Mr. Charlton in his paper, and that is that the introduction of rotary drilling-machines was the means of bringing into use compressed powder in the shape used at all the mines in the Cleveland district and also, to a large extent, the use of squibs, both of which have no doubt increased the safety with which shot-firers and miners can do their work. In the old days, when loose powder and home-made straws were used, as they were with the hand jumper-drill, it would have been a physical impossibility for the shot-firers to do as much work as they do now, to say nothing of the increased safety. At first, compressed pellets were introduced, of the shape of the triangular hole produced by the jumper-drill; but it was found that if the shot-hole was the slightest out of truth the pellets stuck, and, in trying to force them in, many miners have been more or less injured. Afterwards spherical pellets were adopted, with such success that they have been used ever since, for both circular and triangular holes, although with a triangular hole great care has to be exercised, as it is very easy for, say, a "flat-fronted" hole to become "flat-backed," "flat-topped" or "flat-bottomed," or *vice versa;* and, if this occurs, a ledge or canch is formed, at the spot where the change takes place, in the hole, beyond which it is not possible to pass a compressed pellet without using force which is highly dangerous and a breach of the Coal-mines Regulation Act and the special rules current in the district.

Mr. W. CHARLTON, replying to the remarks of Mr. A. L. Steavenson, said that his object in writing the paper was, not to make comparisons between the work of the hand machine-drills and that of the power-drills (both electric and compressed air) so successfully worked in some of the Cleveland mines, but to show how jumper-drills were being superseded by hand-machines. He believed that, in many cases, the hand-machines were as economical as the power-machines, and he was strengthened in that belief by the figures recorded in Table I., showing the great increase in the tonnage wrought by hand-machines in recent years. In some mines, where a portion of the ironstone was won by jumper-drills, and the remainder by power-machines, the former have not been replaced by an extension of the use of the power-machines, but by the introduction of band-machines.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. William Charlton for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. C. C. LEACH read the following paper on "Superheated Steam at Seghill Colliery":—

SUPERHEATED STEAM AT SEGHILL COLLIERY.

By C. C. LEACH.

There are 5 Lancashire boilers, 30 feet long and 8 feet in diameter, 4 are worked at a pressure of 100 pounds and 1 at 40 pounds per square inch, and they provide steam for the pit and shops. When the low-pressure boiler is off, steam is passed through a reducing-valve for use at the winding-engines.

The Dixon superheater (Figs. 1 and 2, Plate XVI.), consists of 33 solid-drawn steel U tubes, $1\frac{9}{16}$ inches in outside diameter, and about 6 feet long, expanded into a steel plate to which is bolted a cast-iron box with a vertical division, which compels the steam from the boilers to enter one side of the tubes, and pass out by the other side, and through 7 inches pipes to the main steam-pipe. Each superheater has a small dead-weight safety-valve; and steel pockets for taking the temperatures of the steam on entering and leaving.

The superheaters are placed vertically, with the tubes hanging downward, in the downtake flue at the back of the boilers, the tubes being exposed to the hot gases as they leave the furnace-flues. The superheaters are carried on a cast-iron frame laid across the opening of the downtake flue.

This superheater is simple, easily fixed, easily removed, and very strong. The makers have recently tested a similar superheater to destruction. At a pressure of 400 pounds per square inch, the joint between the top box and the tube-plate began to shew signs of leakage, which increased and prevented the pressure from rising above 770 pounds per square inch. In a further test, after this joint was remade, a pressure of 900 pounds per square inch was obtained; and, after bearing this pressure for some time, the top of the cast-iron box cracked along the root of the flange.

The first superheater was put in and connected on December

19th, 1901, the pit-year ending 2 days later; 3 other superheaters were connected before the end of the following week; and superheating was thus practically started during the first week of 1902.

No alteration was made to the steam-pipes, beyond taking off the radial pipes, turning the steam-jugs round on the boilers, and coupling the superheaters to the boilers by 7 inches cast-iron pipes. An expansion-joint was taken out of the low-pressure range, and 2 radial pipes inserted, so that the plant is exactly as it was, except for these alterations.

The old covering is still on the old pipes and boilers, and in the usual state of repair: the new 7 inches pipes were covered with magnesium covering, the flanges also being covered.

Nothing whatever (except to keep things in the ordinary working repair), has been done to any of the engines, or to any part of the plant, since the superheaters were put in, so that the tests are made under the ordinary working conditions.

The chimney, 5⅝ feet by 5½ feet at the bottom, is 73 feet high above the grate, and has a water-gauge of only ½ to ⅝ inch. Mechanical stokers are used with moving bars, without forced draught.

Tests of 10 hours were made on 8 days during coal-work in November, 1901, before the superheaters were put in; and on 8 days of this year, so as to ascertain the weight of small coal burnt at the boilers; and 10 hours' tests were also made with nuts, and with duff coal. Table I. contains a summary of these tests.

Table I. compares the saving with the drawings and also with the indicated horsepower, and it may be of interest to know how the horsepower was calculated.

For each winding-engine, a separate card was taken from each end of the cylinder, and for each revolution of the wind. Each revolution was timed to ⅕ second, and from this information the indicated horsepower per wind was obtained. The indicated horsepower was then calculated for any day, from the number of winds based upon the scores drawn.

The hauling-engines were indicated each tenth minute for the 10 hours of coal-work, giving the mean average pressure per revolution. Counters were fixed on the engines, and from the revolutions the indicated horsepower was calculated for each day.

TABLE I.—BOILER-TESTS, WITHOUT AND WITH SUPERHEATING OF THE STEAM.

No of Test.	Superheating or not Superheating.	Date.	Number of Boilers at Work	Description of Coals used.	No. of Days of 10 Hours Coal-work.	Average Weight of Coal burnt per Day.	Ash.	Average Drawings	Average Per cent. of Coal used to Drawings during Coal-work.	Average Total Indicated Horsepower, Donkey-pumps and other small Engines being estimated.	Average Weight of Coal burnt per Indicated Horse-power per Hour.	Indicated Horse-power per Boiler.	Coals burnt per Square Foot of Fire-grate per Hour
						Pounds.	Per cent.	Tons.	Per cent.	Horsepower.	Pounds.	Horsep'wer	Pounds.
1	Not Superheating	Nov., 1901	4	Small coals, with about 16 per cent. of rough nuts	8	31,537	12·40	1,577	0·8928	276·4	11·41	69·1	22·63
2	Superheating	Jan., 1902	4	Do....	1	29,664	14·22	1,671	0·7920	266·0	11·15	66·5	21·29
	Saving on	No. 1 Test	...	...	...	1,873	...	...	11·29	...	0·26*	...	...
3	Superheating	Jan., Feb., March, and June, 1902.	3	Do....	8	27,335	11·04	1,691	0·7218	276·2	9·897	92·1	26·16
	Saving on	No. 1 Test	1	...	...	4,202	...	...	19·15	...	1·513†	...	...
4	Superheating	June, 1902	2	Nuts	2	25,130	10·01	1,630	0·6883	285·9	8·790	142·9	36·08
	Saving on	No. 1 Test	2	...	...	6,407	...	...	22·90	...	2·620‡	...	..
5	Superheating	June, 1902	5	Duff	1	38,864	24·71	1,577	1·1001	281·8	13·79	56·4	22·31
	Loss on	No. 1 Test	1	...	...	7,327	...	...	23·10	...	2·38§	...	..
**6	Superheating	Feb., 1902	2	Small, with about 16 per cent. of rough nuts	1	19,656	11·86	782	1·125	211·6	9·29	105·8	23·21
	Saving on	No. 1 Test	...	...	...	...	...	...	...	...	2·12¶	...	...

* A saving of 2·28 per cent † A saving of 13·26 per cent. ‡ A saving of 22·96 per cent § A loss of 20·8 per cent. ¶ A saving of 18·58 per cent

** Pit only partly at work, i.e. Yard and New Blake Seams.

The fan, pump and electric engines are doing constant work. These were indicated several times and the averages taken, and for the time that the engine was running the power was divided over the 10 hours.

The shop-and-screen engines were indicated every 5 minutes for an hour, and the number of revolutions per minute was taken from the counters.

The power of the two donkey-pumps, stoker, gas, upcast-shaft engine, and steam-hammer, all very small engines, was estimated.

Superheating has enabled the colliery to be worked by 3 instead of 4 boilers, burning the same class of small coal.

The percentage of the coal that is burnt, calculated on the drawings, does not agree with the percentage calculated from the indicated horsepower; nor should it do so, because however the drawings may vary, certain of the engines, such as the fan, run at a uniform horsepower.

Superheating with 4 boilers only effected a saving of 2·28 per cent. of the coals burnt per indicated horsepower per hour, but with 3 boilers the saving was 13·26 per cent. This saving is apparently due to the extra heat obtained in the flue by burning more coal per square foot of grate per hour, and having only 3 instead of 4 boilers to keep hot.

TABLE II.—WATER COLLECTED FROM STEAM-PIPES AND TRAPS.

Outside Surface of Pipes.	Average Weight of Water per Hour.	Weight of Water per Hour per 100 Square Feet of Pipe.	Temperature of Air.
Square Feet.	Pounds.	Pounds.	Degs. Fahr.
2,763	813	29·4	53 Not Superheating
3,036	391	12·8	52 Superheating
Saving by Superheating.	422	16·6	

Superheating with 2 boilers shewed a saving of 22·96 per cent.: this further saving being probably due to the same causes.

The water collected from the pipes and engine-jackets at each steam-trap was averaged for the day; and Table II. records the averages of 5 days.

To ascertain the degree of superheating, the temperatures were taken by 2 mercurial thermometers, tested and corrected at Kew: the steel pockets in the superheaters and engines, being filled with mercury, and the thermometers placed in them. The flue-temperatures were taken by a mercury-thalpotassimeter in the downtake-flue.

The diagram (Fig. 3, Plate XVI.) shews the constant variations of temperatures observed, each minute for an hour, both of the flue and of the steam, for one set of readings. The bars were moving, and the boilers were hand-fired, with a mixture of small coal and 16 per cent. of rough nuts. Table III. contains a summary of the temperatures of the flue and superheater, observed under different conditions: the average of the observations taken at intervals of one minute being recorded.

TABLE III. – TEMPERATURES OF THE FLUE AND SUPERHEATER.

Date.	Kind of Coal.	Number of Boilers Working.	Average Temperature of Flue.	Average Temperature of Superheated Steam	Average Temperature of Saturated Steam.	Degrees of Superheat	Duration of Test.
1902.			Degs. Fahr	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Minutes
July 16	Small with about 16 per cent. of rough nuts	4	942	510	338	172	60
May 22	Do.	3	966	479	337	142	60
,, 23	Do.	3	972	475	339	136	60
,, 23	Do.	3	922	518	339	179	60
June 16	Nuts from Blake Seam	2	1,086	469	335	134	104
,, 19	Nuts from Yard Seam	2	1,122	475	336	139	60
,, 18	Duff	5	837	498	337	151	60

The highest temperature of superheated steam observed at the superheaters was 555° Fahr., when 4 boilers were working, fired with small coal and about 16 per cent. of rough nuts.

Table IV. shews the amount of superheat and the temperature of the steam at the various engines, and also the distance of each engine from the main steam-range.

It may be mentioned that, owing to the increase of temperature of the steam, better cylinder-oil has been used. During the first half-year of 1901, the engines used 144 gallons of cylinder-oil, costing, at 1s. 5d. per gallon, £10 4s., and during the first

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To illustrate Mr. C. C. Leach's Paper eghill Colliery."

DIXON SUPERHEATER.

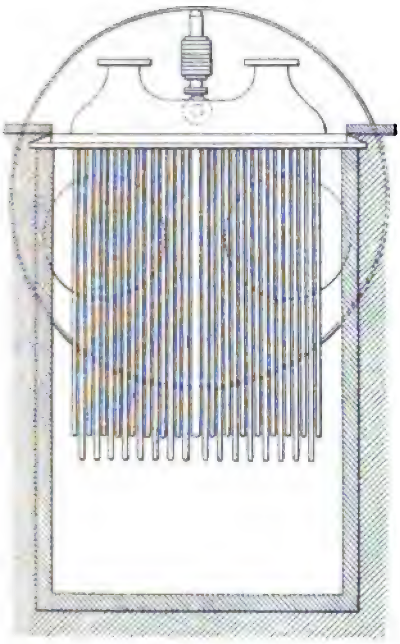


FIG. 1.—SIDE-ELEVATION.

Scale, 4 Feet to 1 Inch.

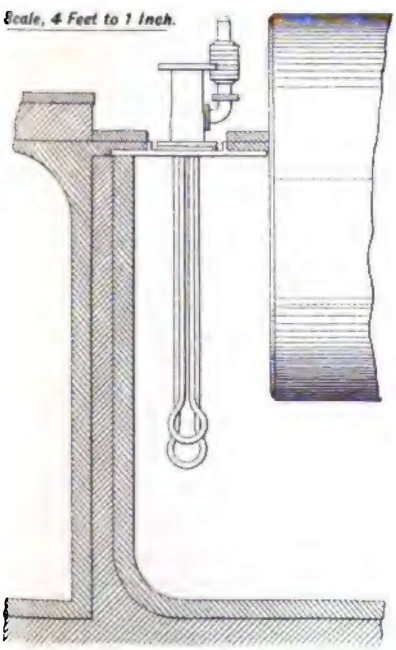
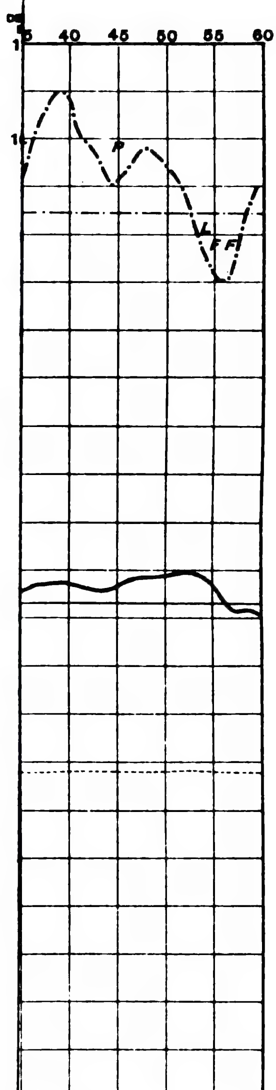


FIG. 2.—END-ELEVATION.

FI ONDING TEMPERATURES OF THE
D OF SUPERHEATED STEAM.
1902.



ES.

— - — -	Poking Fires	P
———	Levelling Fires	L
- - - - -	Firing by Hand	F

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half-year of 1902, when superheating, 136½ gallons of oil were used, costing, at 1s. 9d. per gallon, £11 18s. 10d. This oil has a flash-point of 532° Fahr. in the close test.

TABLE IV. SUPERHEAT OF THE STEAM AT THE VARIOUS ENGINES.

Engine.	Distance from Main Steam-pipe.	Greatest observed Temperatures at Engines.	Degrees of Superheat at each Engine in 1902.					
			June 10th.	July 2nd.	July 4th.	July 7th.	Total	Average
	Feet.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs Fahr.	Degs. Fahr.
John Pit: Winding-engine	106	308	24	11	18	14	67	16·8
Engine Pit: Winding-engine	149	278	- 3	0	- 3	0	- 6	- 1·5
Fan-engine	103	374	34	35	26	32	127	31·8
Pumping-engine ...	46	385	43	47	39	43	172	43·0
Yard Seam: Hauling-engine	201	355	16	4	6	9	35	8·8
Blake Seam: Hauling-engine	151	373	34	21	34	10	99	24·8
Screen-engine	104	358	- 2	2	- 1	- 4	- 5	- 1·2
Shop-engine	618	333	- 5	- 6	- 15	- 6	- 32	- 8·0

NOTE.—Where a minus sign occurs in this table, the supe heat of the steam has been lost, and the lower temperature is due to the pressure of the steam having fallen.

There has been no breakdown of any kind, and the cylinders when examined have shewn no ill effects whatever with the above oil: but it should be noted that all the engines are recent ones, with the exception of the two winding-engines, and none of the larger engines have slide-valves.

Mr. H. C. PEAKE (Walsall) asked whether it had been found necessary to make any alteration in the engine-packing, and, if so, what packing was now used; and what was the approximate cost per boiler of the superheaters.

Mr. J. A. G. ROSS (Newcastle-upon-Tyne) asked whether he correctly understood that there was 20 per cent. of loss from the use of superheated steam with 5 boilers. If so, it was extraordinary, because the generally accepted idea in both theory and practice was that considerable economy was attained by the use of superheated steam; but the great heat imparted to the steam, involved the necessity of high pressures and the use of metallic packing. From Table I., it appeared that with 2 boilers there

was a saving of 22·96 per cent.; with 3 boilers, 13·26 per cent.: with 4 boilers, only 2·28 per cent., and if that curve were continued, they would soon have the extraordinary result that there must be a tremendous saving by having no boilers. A great advantage accompanying the use of superheated steam was not merely the economy, but the advantage in the expansion of the steam. When used in a highly expansive way in the cylinder, the terminal pressure was maintained, and that allowed the initial pressure to be reduced; consequently a lower boiler-pressure could be used, and the various parts of the engine were subjected to lower strains.

Mr. T. H. BAILEY (Birmingham) enquired as to the quality of the water, and whether the pipes of the superheater had been "furred."

Mr. P. KIRKUP (Birtley) asked whether the same kind of packing was used for the steam-pipes, and what was the distance from the superheaters or from the boilers to the engines. In modern steam-practice, it was important, when steam was superheated, that the engines should be placed as near as possible to the superheater. He further asked whether any of the engines were compound and condensing.

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) said that it was generally understood that superheating and drying of steam produced economical results, and he was surprised that they were not more generally adopted. Could Mr. Leach explain which was the most economical system:—Working 5 boilers burning slack, and no superheating, or working 2 boilers with superheating, and burning nut-coals? The results would have been more reliable if all the small engines had been indicated, avoiding the necessity of estimating their horsepower, as it is well known that small engines are wasteful users of steam. He presumed that Mr. Leach took the diagram for each revolution of the winding-engine on each stroke of succeeding winds, the first stroke of the first wind. and the second stroke of the second, and so on to the end.

Mr. R. E. ORNSBY (Seaton Delaval) asked what was the saving, after allowing for interest on capital and depreciation, and reckoning small coal at 5s. per ton.

Mr. W. C. Blackett (Durham) appreciated the amount of hard work involved in making the lengthy experiments which had been recorded in the paper. The subject was a very practical one, and he would be glad to hear the experience of other gentlemen, who had introduced superheating plant at collieries. He asked whether it had been found necessary to make any enlargement of the flues when erecting the superheaters.

Mr. G. A. Mitchell (Glasgow) asked whether any experiments had been made with 3 boilers, working without superheating, which could be compared with the figures when superheating; and whether the chimney was of sufficient size to give full work to the boilers.

Mr. J. W. Fryar (Mansfield) said that as he was using superheated steam, Mr. Leach's paper was of great interest and value. He had experienced difficulty, with superheated steam, in getting the superheat from the boiler to the engine. In a new plant which he had recently erected, superheaters similar to those mentioned in the paper were employed, and although in many cases he had as much as 600° or 700° Fahr. at the superheater, at the engine, 30 or 40 feet distant, there was practically no advantage, despite all pipes and joints being protected with asbestos-covering. Possibly this loss was due to the fact that the engines were not at full work, and did not take steam quickly enough along the pipes from the superheaters.

The Chairman (Mr. J. S. Dixon, Glasgow) said that he was interested in the packing of the joints of steam-pipes; and difficulties were encountered, even with pressures of 120 pounds per square inch.

Mr. C. C. Leach, replying to the discussion, said that there had been no alteration in the engine-packing; metallic packing was used for the piston-rods, except on the two winding-engines and donkey-engines, where ordinary soft packing was used. The cost of the superheater and steam-pipes was about £125 per boiler, but the cost depended partly on the arrangement of the steam-pipes. When there was a loss of 20·8 per cent., this was comparing the weight of duff-coal burned under 5 boilers with the amount of small coal burned under 4 boilers, before the super-

heaters were used; and this loss was due to using the very lowest grade of coal, and in boiling 5 instead of 4 boilers. The diagram (Fig. 3, Plate XVI.) shewed that the amount of superheat was erratic, and it was difficult to explain why one engine obtained superheat and the next engine had none. There had been no alteration as regards the expansion of steam, because all the engines, except the two winding-engines and donkey-engines, were worked expansively. The quality of the water was not good;* it contained a considerable quantity of sulphates (about 30 grains to the gallon), and it was treated with caustic-soda. He could not say whether there was any deposit in the inside of the superheater-pipes, as he had not seen them. The water did not go into the superheater, except what little might prime over, and steam did not leave any "furring." No packing was used for the steam-pipes, metal-to-metal joints were used with elastic cement between them, and therefore nothing could blow out or be burnt. The cement was plastered on to corrugated rings, and the joints were closed with nuts and bolts. Manganese-cement had been used, but it was no better than the ordinary cement employed at the colliery, and they continued using the latter The distances from the engines to the boilers was one of the difficulties of deciding if superheat would be of any advantage, and the engine nearest to the boilers showed the most superheat. None of the engines were compound, and the two vertical winding-engines and the pumping-engines were the only ones fitted with condensers. All the pipes were cast-iron, with planed joints, and there had been no breakdowns or fractures.

He had no information as to the result of working 3 boilers without superheating, as 3 boilers without superheating did not supply sufficient steam for the requirements of the colliery. The chimney was 73 feet high, and small for the work; but if the draught had been better, it is probable that higher results would have been obtained with the inferior coals. As to the relative economy of firing 2 boilers with small coal or 5 boilers with duff-coal, if the members fixed their own prices on the different kinds of coal they would see which cost the least.

He (Mr. Leach) would not have been able to indicate so many of the engines as he did, except for the able assistance afforded him by his engineer and mining-apprentices. The winding-engines were indicated during each revolution of a wind: the

* The total solids are 118 grains in 1 gallon of the water.

first revolution being taken of one wind, and the next revolution of the second, and so on for the top end of the cylinder, and similarly for the bottom end, and the time was taken with a racing watch, to 0·2 second.

There was a difficulty in getting the superheat to the engines, as it was speedily dissipated. It was perhaps more difficult at Seghill colliery, because most of the steam-pipes were too large in diameter, and presented a large cooling-surface, and the covering on the pipes, when the experiments were made, had been upon them for some years. Since then, new covering had been put on to the pipes. In the case of the engine receiving no superheat, of course it was being lost: it was difficult to prevent radiation; possibly the places of loss might be discovered by taking the temperatures in pockets on the steam-pipes. There was little alteration to the flues; these were rather narrow, and had been widened to take in the cradles and the superheaters.

The horsepower of the donkey-engines having been calculated (and not indicated), did not alter the results, because they were all at work before superheating was introduced, and altogether they did not amount to much. The question of expansion in no way altered the results, because all the engines were working exactly as they did before. The governors cut off the steam automatically and, naturally, did so earlier when there was less condensation in the cylinders (due to the superheating) and this was one part of the economy. High economy could not be obtained without much greater strains, but these did not increase the risks with proper machinery. Although the superheat might have disappeared before the steam reached the engine, the steam was drier, or, at any rate, had not had so much water condensed out of it, in the pipes, and therefore, even in these cases he (Mr. Leach) believed that there was a saving. Superheated steam was said to travel more quickly through pipes than saturated steam; but there seemed to be no tests to prove this or its extent, or how much smaller the steam-pipes ought to be. The use of superheated steam increased the speed of the winding, but he (Mr. Leach) had not sufficient records from which to compute a reliable average.

From the end of No. 3 pay, 1902, by which time the superheaters were worked properly, to the end of No. 25 pay, or 44 weeks, the coal burnt at the boilers day and night was

1·1233 per cent. of the drawings, and the lowest fortnightly average was 1·01 per cent.*

The CHAIRMAN (Mr. J. S. Dixon), in proposing a vote of thanks to Mr. C. C. Leach for his valuable paper, remarked that of the coal produced, about 1 per cent. was used during coal-work at Seghill colliery for steam-production. He thought that this was a very low figure, and he understood that $7\frac{1}{2}$ per cent. was not considered unreasonable at many collieries.

Mr. W. C. BLACKETT (Durham), in seconding the vote of thanks, said that most of the members knew how much time and trouble had been taken by Mr. Leach to secure the most economical results at Seghill colliery. The paper was particularly interesting, as shewing the application of the principle of superheating steam at an old colliery. He would be rather ashamed of any colliery, under ordinary conditions, in Durham or Northumberland, at which the coal used both for engines and the supply of fire-coal to workmen reached $7\frac{1}{2}$ per cent. of the production.

The vote of thanks was cordially approved.

Mr. J. B. SIMPSON read the following paper on "The Probability of Finding Workable Seams of Coal in the Carboniferous Limestone or Bernician Formation, beneath the Regular Coal-measures of Northumberland and Durham, with an Account of a recent Deep Boring made, in Chopwell Woods, below the Brockwell Seam":—

* The coal burnt at the boilers, day and night, in 1902, was 1·1179 per cent. of the drawings, and the lowest fortnightly average was 1·01 per cent.

THE PROBABILITY OF FINDING WORKABLE SEAMS OF COAL IN THE CARBONIFEROUS LIMESTONE OR BERNICIAN FORMATION, BENEATH THE REGULAR COAL-MEASURES OF NORTHUMBERLAND AND DURHAM, WITH AN ACCOUNT OF A RECENT DEEP BORING MADE, IN CHOPWELL WOODS, BELOW THE BROCKWELL SEAM.

By J. B. SIMPSON.

I. Introduction.

The Royal Coal Commission in 1871, in estimating the quantities of coal remaining unworked in the counties of Northumberland and Durham, dealt first with the coal in the upper or regular Coal-measures and then with the coal in the Lower Carboniferous rocks where they appear on the surface over a large area, chiefly in Northumberland. The Royal Commissioners seem to have disregarded the probability of coal being found in the Limestone-measures which underlie the regular Coal-measures of the Great Northern coal-field.

The writer, in his address to the Students of the Newcastle Branch of the Institution of Civil Engineers in 1896, referring to this point, said:—

> I may add that the Carboniferous or Mountain Limestone formation is not only found in the greater portion of Northumberland and a considerable portion of Durham, but it will naturally underlie the whole of the Northumberland and Durham coal-field. In fact, beneath our feet is another unexplored coal-field, and it would be a most interesting geological investigation, as well as of truly commercial and national importance, if workable seams at moderate depths could be proved. If this should be the case, and coal could be worked therefrom, it would be preferable to working from the same formation in the middle of Northumberland, as it would enable the present shafts and railways to be utilized and extended for its winning. Bore-holes, in the first instance, would throw a considerable light on the subject, and could, with no great expense, be made from the bottom of some of our shafts from what is usually termed the lowest workable seam, the "Brockwell." From this point, there are not supposed to be any seams of much importance until the Limestone formation is reached, and it is probable that coal of workable thickness may be met with within 1,000 feet below the Brockwell seam.

The object of this paper is to record what is known of the seams of coal, either by actual sinking or by bore-holes beneath the Brockwell seam, and to consider chiefly what prospects there are of workable seams being found, especially in the Mountain Limestone-formation under the regular Coal-measures.

From what is known of the occurrence of coal-seams under the area where the Lower Carboniferous formation comes to the surface, it is reasonable to suppose that those seams may continue under the regular coal-field; and, if so, their working would add considerably to the duration of our northern coal-field. From the former area, for many years, coal has been worked and is now being worked, in many places, at the outcrop and from shallow pits, but the output is not large and the quality of the coal in many places is inferior.

The geological map (Fig. 1, Plate XVII.), shews the area of the various formations in Northumberland and Durham, and it will be seen that the Carboniferous Limestone and Millstone Grit occupy extensive areas as compared with the regular Coal-measures, the relative areas being 1,500 square miles of the former and 700 square miles of the latter (including the coal under the Permian formation), the coal under the sea not being taken into consideration in either case.

II. Regular Coal-measures.

It is not necessary to refer to these more, than to say that their total thickness may be taken at 1,850 feet down to the base of the Brockwell seam, and in this depth there are about 26 seams of coal, varying from 12 inches to perhaps 7 or 8 feet in thickness, and amounting in the aggregate to about 80 feet.

III. Millstone Grit Series.

For present purposes, these measures include the strata from the Brockwell seam, including the Millstone Grit proper, to the top of the Lower Carboniferous Limestone. This depth is estimated by Mr. Westgarth Foster, and others, at about 600 feet, but few direct borings have been made from the Brockwell seam direct to the limestones. At Tudhoe colliery, it is recorded that a bore-hole met with limestone, 3½ feet thick, at a depth of 514 feet below the Brockwell seam. The recent borings made in Chopwell Woods (which we shall discuss further on) went direct to the limestone,

passing through several beds, and met with the first limestone at 481 feet below the Brockwell seam (probably this was the Fell Top limestone).

In this depth or zone, some 3 or 4 thin coal-seams varying from 6 inches to 2½ feet in thickness, and not more than 6 feet in all, have been found in various localities in the upper portion, but only two seams appear to be worked in any locality and that only at a few places in the two counties (Fig. 2, Plate XVIII.).

On Tyneside, the only place where a seam has been worked in this zone has been at Eltringham colliery, near Prudhoe. There, the Brockwell seam is found at a depth of 187 feet 8 inches; and the shaft was sunk further to the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.	Depth below the Brockwell Seam. Ft.	Ins.
No. 1	1	6	11	9
No. 2	0	6	29	4
No. 3	1	3	45	9
No. 4, cannel	1	6	83	10

The lower seam was worked for a few years, its average thickness being: cannel, 2 feet; and coal, below, 1 foot. The working has been abandoned, owing to the cannel having been replaced by inferior coal.

At West Wylam colliery, a stone-drift has proved the following thin seams below the Brockwell seam:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.	Depth below the Brockwell Seam. Ft.	Ins.
No. 1	0	6	22	3
No. 2	0	4	28	7
No. 3	1	0	30	7
No. 4	0	6	37	10
No. 5	0	7	54	11
No. 6	0	9	72	8
No. 7	0	9	141	5
No more coal was proved down to	...		210	2

At Hedley landsale colliery, 2 miles south-east from Stocksfield station, a boring proved the following seams below the Brockwell seam:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.	Depth below the Brockwell Seam. Ft.	Ins.
No. 1	0	6	48	8
No. 2	0	6	57	1
No. 3	1	5	76	3
No. 4	0	6½	108	0
No more coal was proved down to	...		186	0

In Stella village, near Blaydon, a boring made there met with the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 4	16 9
No. 2	1 1	69 5
No. 3	1 6	85 11

At Chopwell colliery, a bore-hole was put down below the Brockwell seam in 1795, but only thin seams were met with as follows:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 1	45 9
No. 2	0 1	80 5
No. 3	0 1	94 4
No. 4	0 9	108 4
No. 5	0 2	148 7
No. 6	0 9	196 6
No. 7	0 3	223 6
No. 8	0 5	270 9

At Redheugh colliery, a boring below the Brockwell seam, at a depth of 575 feet 4 inches, proved the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 0	76 11
No. 2	0 9	87 2
No. 3	1 1	104 9
No. 4	0 8	125 2
No more coal was proved down to	...	158 3

A bore-hole from the Low Main seam at the B pit, Backworth colliery, proved the following seams, commencing at a depth of 649 feet 7 inches:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Low Main Seam. Ft Ins.
No. 1	2 6	275 7
No. 2	0 7	282 3
No. 3	1 11	358 2
No. 4	2 1	382 0
No. 5	2 9*	492 2
		Depth below the Brockwell Seam.
No. 6	0 4	54 5
No. 7	1 6	69 4
No. 8	1 3	96 6
No more coal was proved down to	...	108 10

* This may be the Brockwell seam, from its position.

At Cramlington colliery, below the supposed Brockwell seam in the Betsy pit, the following seams have been proved by a bore-hole:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1, including 6 inches of band	1 11	33 11
No. 2	0 4	48 3
No. 3	0 10	88 7
No. 4	0 10	145 2
No. 5, including 16 inches of band	2 9	189 10
No. 6	0 10	317 11
No. 7	0 8	361 3
No more coal was proved to	...	412 7

These bore-holes, etc., seem to exhaust all that is known in the Tyneside district. It is possible that, in some localities, these seams may be of greater thickness, but up to the present time the information we have proves that in this zone the two seams of any moment do not exceed from 1 foot to 2 feet each.

In South Durham, the record is about the same. At Witton Park colliery, a boring made below the Brockwell found the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam Ft Ins.
No. 1	0 4	47 0
No. 2	0 6	73 1
No. 3	1 5	77 6
No. 4	0 4	124 2
No. 5	1 8	127 1
No. 6	1 8	177 4
No. 7	0 7	225 9
No more coal or limestone was proved down to	...	630 2

Another bore-hole in Beechburn royalty, not far distant, gave the following result:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1 or Victoria	2 0	70 3
No. 2 or Marshall Green	1 5	128 0

At Tudhoe colliery, a boring below the Brockwell seam found the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.	Depth below the Brockwell Seam. Ft.	Ins.
No. 1	0	1	13	11
No. 2	0	6	140	6
No. 3	0	4	166	10
No. 4	0	4	227	4
No. 5	1	6	338	0
Limestone	3	6	514	0
No more coal or limestone was proved down to	...		609	0

The Victoria coal-seam has been found at Beechburn, Broompark, Butterknowle, Coldknott, Etherley, Harperley Gate, Witton Junction, and Woodifield; and it is (the writer believes) only worked at one or two of these places, the height being not more than 2 feet.

The Marshall Green coal-seam is worked, in a limited way, at Marshall Green colliery.

There is, therefore, little to be expected from what is already known in the Tynedale and south-western Durham districts of the seams in the middle zone between the Brockwell seam and the Limestone series; and we are not aware that the record is any better in any other parts of the coal-field.

IV. Lower Carboniferous or Bernician Formation.

As already mentioned, the Bernician formation comes to the surface over a large area of Northumberland and Durham. Its thickness is supposed to vary in different districts, and it consists of several beds of limestone, sandstone, shale and ironstone, and several seams of coal. Probably, the least thickness of the Limestone coal-bearing measures is 4,000 feet, below which follows a great thickness of grits and shales down to the old Red Sandstone formation.

Many papers have been written by members of the North of England Institute of Mining and Mechanical Engineers and others concerning the geological features of this formation, and the maps of the Geological Survey give the outcrops of the various limestones and beds of coal, in much detail; but there is still great difficulty in the correlation of these various beds, which can only be elucidated by the further mining operations of boring and sinking, and the careful tracing of the various beds and their fossils from one district to another.

From Mr. Westgarth Forster's section of the strata of the western district made many years ago, and a section prepared by

Messrs. William and John Wilson and given by Mr. M. Walton Brown in a paper read by him before the members of the North of England Institute of Mining and Mechanical Engineers,* and from the knowledge which we now possess it would appear that there are two distinct zones whence coal has been worked and which for mining and geological purposes may appropriately be named:—(1) The Blenkinsopp, Acomb and Shilbottle series; and (2) the Plashetts and Scremerston series.

No. 1 Series.—No. 1 series may be taken as about 1,500 feet thick. The chief seams comprized in it are the Fell Top coal, about 2 feet thick; the Oakwood seam, 2 feet; the Blenkinsopp or Acomb seam, from 2 feet 8 inches to 4 feet; and the Shilbottle or Licker seam, the lowest of the series, about 2 feet 6 inches.

The following collieries, marked on the map (Fig. 1, Plate XVII.), are at present being worked in this zone and in the seams of the thicknesses mentioned:—

Names of Collieries	Names of Coal-seams.	Thickness of Coal-seams. Ft. Ins. Ft. Ins.
Blenkinsopp	Acomb	3 2 to 3 11
Melkridge or Blackett	,,	1 10 ,, 2 2
Haltwhistle or South Tyne	,,	2 0 ,, 2 5
Thorngrafton	?	1 10 ,, 2 0
Fourstones	Acomb	2 4 ,, 4 0
Fallowfield	,,	3 0 ,, 4 6
Acomb or Tynedale	,,	—
Whetstone, Killhope	Fell Top	2 6
Coldcleugh	Acomb	2 4
Halton	,,	1 5
Whittington	,,	1 8
Kirkheaton	,,	2 8
Sooty Row	?	2 4
Longframlington	Shilbottle	2 6
Longhorsley	,,	2 6
Netherwitton	,,	2 8
Newton-on-the-Moor	,,	2 10
Shilbottle	,,	2 0
Wallshield	,,	2 0

There has been a great development of coal-working in the Haltwhistle district, chiefly at Blackett colliery, and this district, in consequence of the favourable nature of the coal, will in future years be further developed.

* *Trans. N.E. Inst.*, 1887, vol. xxxvii., page 16.

No borings have been made below the Blenkinsopp seam, to prove the whole of the upper zone, or the existence of the seams in the lower zone. However, the time will soon come, when explorations will be attempted.

No. 2 Series.—No. 2 series may be taken as probably 1,800 feet thick, but none of the seams in it have been proved or sunk to in the area where the seams in the upper zone are worked.

There are several coal-seams, the chief seams of the Scremerston district being named as follows:—The Eelwell coal, the Greenses or Beadnell seam, the Muckle Howgate seam, the Little Howgate seam, the Fawcett coal, the Scremerston Main coal, the Hardy coal, the Cancer seam, the Three-quarter coal, the Cooper-eye coal, and the Wester coal-seam. These seams vary in quality, and the thicknesses range from 2 to 4 feet, including bands of shale.

In the Plashetts district, also in this series, the chief seams are the Hareshaw Head, Haining-rigg, Furnace, Cariteth, Plashetts, Shilburnheugh and Lewis Burn coal-seams.*

The following collieries are working one or more of these seams:—

Names of Collieries.	Thickness of Coal-seams. Ft.	Ins.
Fourlaws	2	0
Hareshaw Head	2	8
Gunnerton	2	2
Shilburnheugh	2	0
Plashetts	4	0
Brownrigg	2	6
Elsdon	2	0
Chatton	2	0
Licker	2	0
Scremerston	3	6
Felkington	2	0

The chief collieries working coal from this zone are at Plashetts and Scremerston. The seam worked at Plashetts colliery has been assumed to lie in about the same horizon as the Scremerston Main seam. Its thickness is about 4½ feet, and it is estimated to extend over a large area. At Scremerston colliery, although the district

* Since reading this paper, the author has been informed that several bore-holes have recently been made in the Greenhead and Walltown district, and coal-seams have been found, one, 3 feet thick, evidently belonging to the lower zone or No. 2 series. This augurs well for other seams of the Scremerston and Plashetts series being found in future explorations.

abounds in many seams of coal and is of large extent, there is at present only one seam being worked, namely, the Cooper-eye seam.

The writer has estimated the total output of the 36 collieries working Limestone coals at 478,000 tons, the greater portion, about 66 per cent., being obtained from the first series of seams.

Coal has been worked in many other places in the Carboniferous Limestone formation, and it may be interesting to know that working took place in some localities at an early period. It is recorded that coal was worked at Middleholm, near Mitford, in 1250; at Buteland, near Bellingham, in 1296; in 1418, at Shoresworth, near Berwick; in 1440, the monks of Holy Island expended £2 6s. 8d. in sinking a pit at Howburne; in 1455, at North Sunderland; in 1473, further expense was incurred by the Earl of Northumberland at Bilton, near Alnmouth, in connection with the sinking of a new coal-pit; in 1510, at Tweedmouth, Scremerston and Ford; and in 1532, 1567 and 1663, coal was being worked at Shilbottle. In 1547, the lord of Hexham manor received rent for a coal-mine at Fallowfield.*

Cumberland and Yorkshire.—Coal is being worked in the Bernician formation in north Yorkshire and in east Cumberland, but as this hardly falls within the scope of the present paper and as the writer does not possess much knowledge of these districts, he has omitted them from present consideration.

Resources.—There is no doubt that this Bernician formation is capable of further development; and, when the coal from the Upper Coal-measures becomes more scarce and more costly to work, the Bernician coal will come more into play, especially if railways be further extended and the cost of railway-carriage be decreased.

The quality of the coal in some of the districts has not been found equal to that from the true Coal-measures, but it must be borne in mind that the coal in all instances is worked from shallow depths. Some of the collieries produce extremely good coal: for instance, Shilbottle has a first-class house-coal while Blenkinsopp, Blackett, and others yield a good manufacturing and coking coal.

* "Extracts from the Account Rolls of the Abbey of Durham," in three volumes, *The Publications of the Surtees Society*, vols. xcix, c., and ciii.

Mr. M. Walton Brown, in a paper read by him before the North of England Institute of Mining and Mechanical Engineers,* in referring to this formation, mentions that the Royal Coal Commission in 1871 estimated the quantity of available coal at 665,000,000 tons, and he states that "the available areas and the thickness of seams have been under-estimated. Thus, in the Scremerston district, the seams appear to be from 54 to 73 feet in aggregate thickness. This development is not found in other parts of the Mountain Limestone, as in the more southern districts not more than four seams are found, which are only of workable thickness in small areas. In an area of 1,200 square miles in the northern part of this coal-field (omitting the portions covered by the Upper Coal-measures) it may be assumed that there is at least 10 feet in thickness of workable coal. The contents of 1 square mile of this thickness will be 9,600,000 tons and of 1,200 square miles will consequently be 11,520,000,000 tons. After an ample allowance for dykes and other interruptions there will probably remain an available supply of 8,000,000,000 tons." There can be no doubt that Mr. Walton Brown is correct in saying that the figures of the Royal Commission were under-estimated, but they will doubtless be revised by the Royal Commission recently appointed, in the light of our present knowledge of the district.

Covered areas.—We now come to consider the probability of coal of workable thickness being found under the area occupied by the Millstone Grit and under that of the regular Coal-measures.

There have been few borings made directly from the regular Coal-measures to the Carboniferous Limestone. At Tudhoe colliery, a boring was made some years ago, and at a depth of 514 feet below the Brockwell seam a bed of limestone, 3½ feet thick, was proved; the boring was extended to a further distance of 95 feet, but neither coal nor limestone was found.

Chopwell Bore-hole.—By the enterprise of Messrs. Priestman & Company, of the Garesfield Coal Company, and with the assistance of H.M. Commissioners of Woods and Forests, some further light has been thrown on the strata lying below the Brockwell seam, by a deep bore-hole which was put down in 1897 in Chopwell Woods, near Lintz Green and the river Derwent.† The

* *Trans. N.E. Inst.*, 1887, vol. xxxvii., page 10.

† Longitude, 1° 46′ 35″ west; and latitude, 54° 55′ 40″ north.

particulars of this section are set forth in Appendix I. and in a section (Fig. 3 Plate XIX.). This bore-hole commenced at a position in the strata assumed to be 166 feet below the Brockwell seam, and passed through the following beds of coal:--

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth from Surface. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 4	19 0	185 0
No. 2	0 1	74 1	240 1
No. 3	0 1	680 11	846 11
No. 4	0 4	1,054 1	1,220 1
No. 5	0 2	1,186 3	1,352 3
No more coal was proved down to ...		1,318 0	1,484 0

The bore-hole passed through the following limestones:—

Limestones.	Thickness of Limestones. Ft. Ins.	Depth from Surface. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 11	315 3	481 3
No. 2	6 1	416 9	582 9
No. 3	18 10	491 9	657 9
No. 4	2 8	557 10	723 10
No. 5	15 8	634 11	800 11
No. 6	7 2	844 8	1,010 8
No. 7 or A	12 2	1,010 6	1,176 6
No. 8	6 10	1,084 5	1,250 5
No. 9 or B	50 2	1,148 1	1,314 1
No. 10 or C	20 2	1,303 5	1,469 5

It was assumed, from all the information that we had connecting the Upper Coal-measures with the Carboniferous Limestone formation, that the latter might be met with at about 600 feet below the Brockwell seam. This bore-hole met the first bed, probably the Fell Top Limestone, at a depth of 481 feet; it was however, only 1 foot 11 inches thick.

Then, as to coal, we assumed that the Blenkinsopp or Acomb seam might be found at a depth of about 1,000 feet. The first coal in the Carboniferous Limestone formation was met with at a depth of 847 feet below the Brockwell seam, its thickness being only 1 inch. At 1,220 feet, a 4 inches seam was passed through, and at 1,314 feet, a limestone, 50 feet thick, was reached: it may be the Great Limestone. Comparing the position of the coal-seams and limestones met with in this section, and that of Tynedale, it would appear that the letters A, B and C are the relative positions of the limestones in each section; and, it may

almost be concluded that the coal, 4 inches thick, is the representative of the Acomb coal-seam.

At 1,352 feet, another seam, 2 inches thick, was reached, and this might represent the Shilbottle seam of the northern district, but it is difficult to make a definite correlation on such slender data.

The bore-hole has been disappointing, especially as it attained a depth of 1,484 feet below the Brockwell seam, and no coal was found of workable thickness, but only five seams of 4 inches, 1 inch, 1 inch, 4 inches and 2 inches respectively. Of course one bore-hole, only 4 inches in diameter, is not sufficient to condemn the whole area as barren of workable coal. It is, however, so far satisfactory that coal and limestone have been found in about the stratigraphical positions in which they were expected.

From a comparison of the sections that the writer has compiled, it will appear that from the position of the limestones in the bore-holes and from their assumed positions in the western and northern districts, it is almost impossible to correlate them until much more information is obtained.

It may, however, be concluded that the Great Limestone, B, in the Tynedale section of Mr. Westgarth Forster occurs at 979 feet below the Brockwell seam and is 63 feet thick; in the Chopwell bore-hole it would appear to lie at 1,314 feet below and to be 50 feet thick; and at Scremerston, it may be assumed to occur at 1,036 feet and to be 28 feet thick.

It seems most unlikely that workable seams of coal, which are found close to the outcrop of the Millstone Grit and extending over so many miles, should suddenly come to an end, or continue only a few inches in thickness under the Millstone Grit and the superimposed regular Coal-measures. We have also the fact that in Midlothian, the Mountain Limestone formation contains many workable seams, which are sunk to through the regular Coal-measures and Millstone Grit series lying above them. Perhaps it may be that the Chopwell bore-hole did not go deep enough, as there is a thickening of the strata going eastward, and this might throw the coal-seams deeper; or it is possible that the bore-hole might go down on a local "nip," or that the thickness was not correctly ascertained. There is no doubt that the seams in the Mountain Limestone do vary in thickness, and make it difficult to trace the seams over a large area. For instance, the Acomb seam

as found near Hexham is 4 feet 6 inches thick, while in the Allenheads district it is represented by only a few inches of coal.

The writer may mention that near Stockton several bore-holes were put down, and in one or two instances it is supposed that after passing through the Permian formation (the true Coal-measures being absent) the Mountain Limestone formation was met with and bored into. In one of the bore-holes, the lime-stone was reached at a depth of 1,479 feet, and coal, 2 feet thick, was met at a depth of 1,952 feet.* This is, of course, a thin seam, but it is so far satisfactory, as it favours the idea that coal-seams may be continuous from the northern district under the regular Coal-measures, into the Stockton district.

The Chopwell bore-hole, above mentioned, has not at any rate explored the whole depth of the Carboniferous Limestone-measures and has probably not gone through the upper zone. Below the depth reached, there should follow all the strata down to the Old Red Sandstone, and therein the several seams of coal and beds of limestone of the Scremerston and Plashetts districts should be found, and this might reach a total depth of 4,000 feet below the Brockwell seam. But if some of the seams should not be reached within a depth of 2,000 feet or 3,000 feet below the Brockwell seam, they would in the deeper parts of our coal-field be quite beyond a workable depth, according to our present commercial ideas.

The writer is still of opinion, however, that further explorations may well prove large areas of coal of workable thickness at accessible depths, and as coal becomes more scarce they will be proved and worked. The question, however, can only be settled definitely by further borings and sinkings being made in the different districts; and no doubt, in time, these will be carried out.

In considering our national supplies of coal, the subject becomes an important one, especially in the future industrial interest of Northumberland and Durham, and the writer has no doubt that the present Royal Commissioners will endeavour to obtain all the available information so as to enable them to offer an opinion on the probabilities of an additional supply from the areas which have been brought under consideration in this paper,

* *Trans. Inst. M.E.*, 1890, vol. i., page 362.

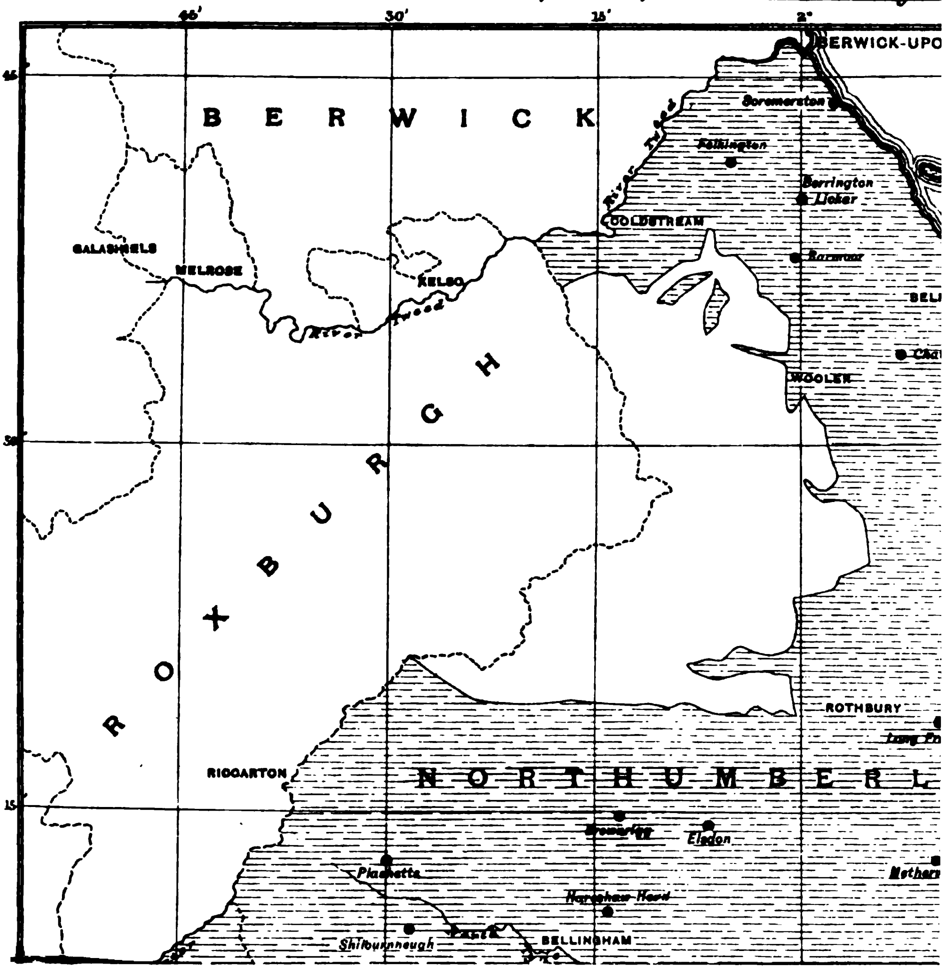
and which did not enter into the estimate of the former Royal Coal Commission of 1871.

In conclusion, the writer must apologize for bringing forward a paper of a somewhat speculative character, but at the same time he hopes that the attempted record of our present practical knowledge of the coal-seams in the formations beneath the Upper Coal-measures may be of some use in the future elucidation of the scientific and economic geology of the two counties.

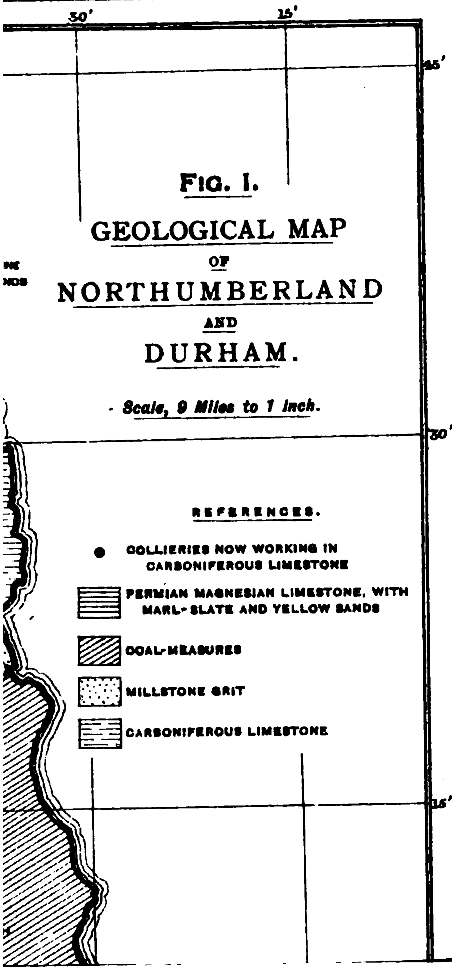
APPENDIX I.—Section of Strata in a Bore-hole near the River Derwent in South-eastern Corner of Boundary and 136 Chains West of Lintz Ford Mills, Chopwell Woods, at a position in the Strata supposed to be 166 Feet below the Brockwell Seam.

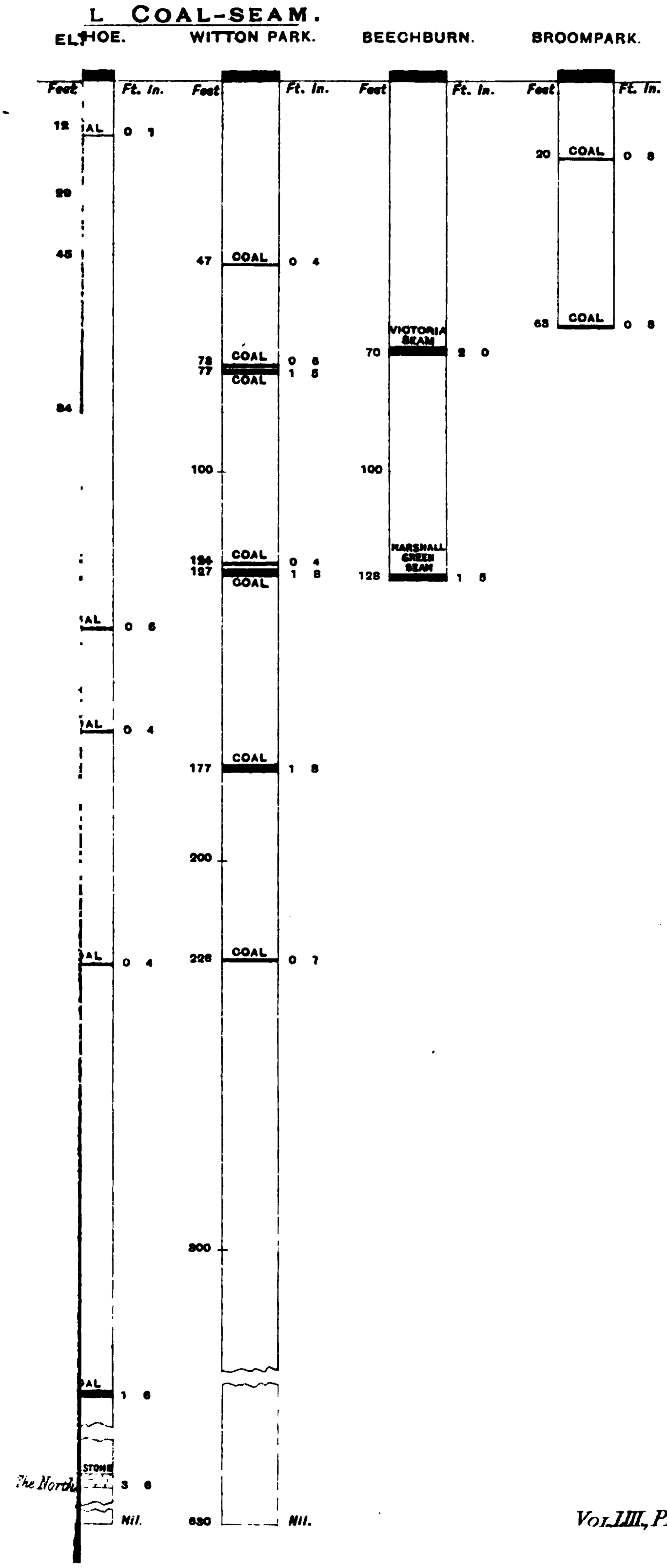
No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Clay, sand and soil	4	6	4	6
2	Boulder-clay ...	12	0	16	6
3	Broken freestone	0	8	17	2
4	Very dark grey shale	1	6	18	8
5	**COAL**, very coarse	0	4	19	0
6	Dark grey shale ...	2	0	21	0
7	Grey sandstone ...	18	0	39	0
8	Grey sandstone and thin shale-partings ...	8	6	47	6
9	Very dark grey shale	0	10	48	4
10	Soft grey shale, with post-girdles	4	6	52	10
11	Dark grey shale ...	3	8	56	6
12	Strong grey post	2	1	58	7
13	Soft dark grey shale	15	5	74	0
14	**COAL**	0	1	74	1
15	Seggar	2	6	76	7
16	Dark grey shale ...	4	9	81	4
17	Strong grey post	11	0	92	4
18	Dark grey shale ...	3	10	96	2
19	Strong grey post	6	2	102	4
20	Dark grey shale	11	0	113	4
21	Strong grey post, laminated ...	61	7	174	11
22	Dark grey shale	21	6	196	5
23	Very strong grey post	16	0	212	5
24	Seggar	0	9	213	2
25	Soft dark grey shale	1	6	214	8
26	Light grey post ...	10	0	224	8
27	Dark grey shale ...	7	0	231	8
28	Very strong light grey post ...	5	2	236	10
29	Dark grey shale ...	18	2	255	0
30	Light grey post and *coal*-threads	2	0	257	0
31	Seggar	2	4	259	4
32	Dark shale ...	4	1	263	5
33	Grey post .	1	0	264	5
34	Dark grey shale ...	6	2	270	7
35	Grey shale, with post-girdles	3	9	274	4
36	Grey post, with metal-partings	24	6	298	10
37	Dark grey shale ...	14	6	313	4
38	*Limestone*, grey ...	1	11	315	3
39	Coarse grey seggar	2	2	317	5
40	Grey post, with shale-partings ...	8	1	325	6
41	Grey shale ...	8	0	333	6
42	Coarse seggar ...	1	0	334	6
43	Grey post, with threads of shale	12	7	347	1
44	Grey shale ..	5	1	352	2
45	Dark grey post ...	6	2	358	4
46	Seggar, coarse ...	2	1	360	5
47	Grey post, with shale-partings ...	33	0	393	5
48	Dark grey shale, with post-girdles	10	2	403	7
49	Hard grey post ...	7	1	410	8
50	Dark shale, with *limestone* and shells	6	1	416	9
51	Grey post, very coarse & strong	32	11	449	8
52	Grey shale, with post-girdles ...	23	3	472	11
53	*Limestone*, and occasional shaly partings ...	18	10	491	9
54	Grey post ...	12	1	503	10

To illustrate Mr. J. B. Simpson's Paper on "The Probability o



le Seams of Coal," etc.




L COAL-SEAM.
EL...HOE.
WITTON PARK.
BEECHBURN.
BROOMPARK.
Feet
Ft. In.
COAL
VICTORIA SEAM
MARSHALL GREEN SEAM
STONE
Nil.
12
29
45
84
47
73
77
100
124
127
177
200
226
300
630
70
128
20
63
0 1
0 4
0 6
1 5
0 4
1 8
1 8
0 7
2 0
1 5
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0 8
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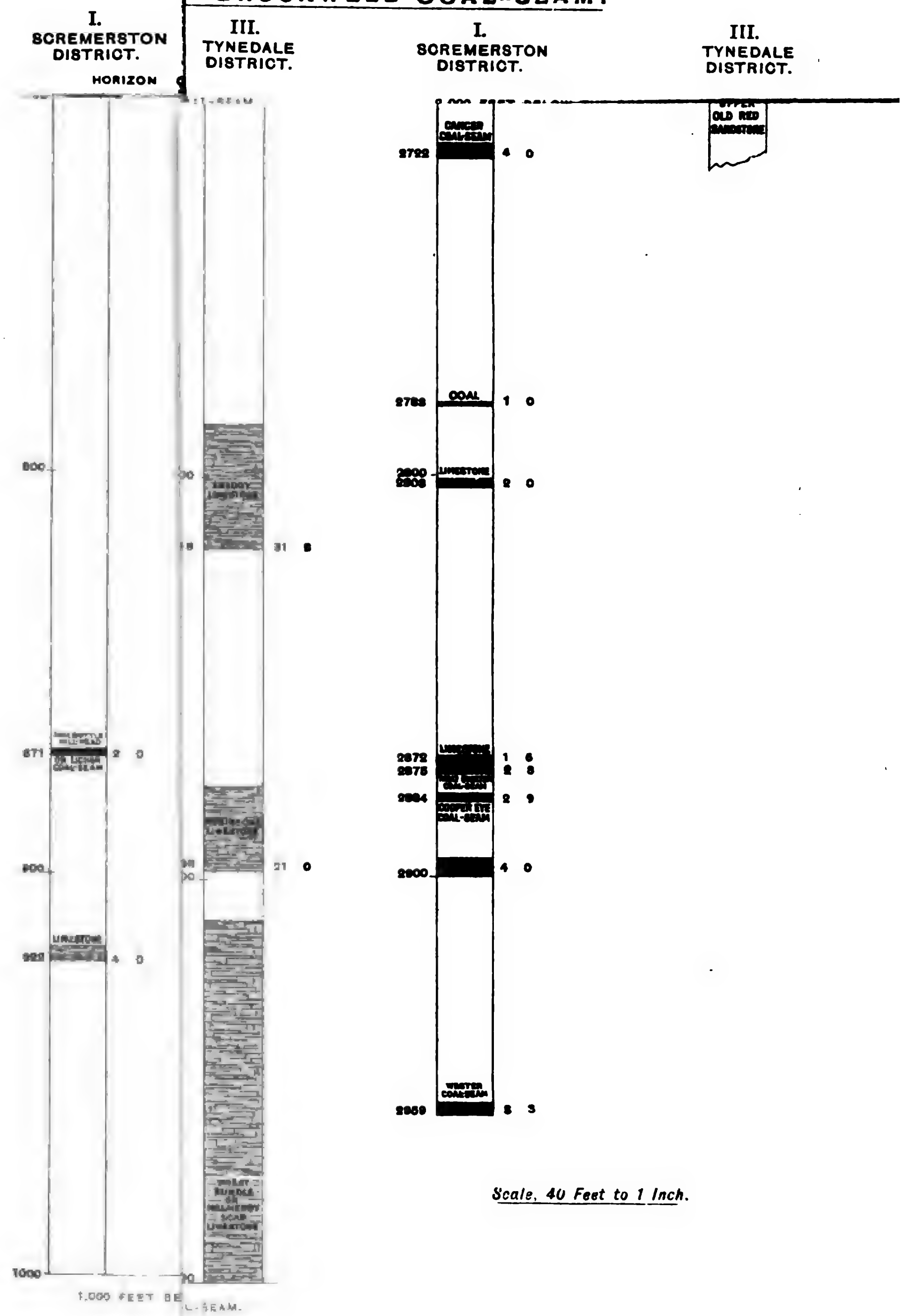
3 6

of finding Workable Seams of Coal," etc.

BROCKWELL COAL-SEAM.



Scale, 40 Feet to 1 Inch.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
55	Dark grey shale ...	6	3	510	1
56	Grey post ...	12	5	522	6
57	Grey shale ...	2	8	525	2
58	Dark grey post ...	1	4	526	6
59	Dark grey shale, with ironstone-bands	21	0	547	6
60	Grey post, with much silica and shale-partings	7	8	555	2
61	*Limestone*, grey ...	2	8	557	10
62	Coarse grey post	50	11	608	9
63	Grey post and shaly partings, with threads of *coal*	5	5	614	2
64	Dark grey shale	5	1	619	3
65	*Limestone*, grey ...	15	8	634	11
66	Grey post, with shaly partings	19	3	654	2
67	Grey slate, with post-girdles ...	10	11	665	1
68	Strong grey post ...	15	9	680	10
69	**COAL**, coarse ...	0	1	680	11
70	Dark grey post, with shaly partings	23	6	704	5
71	Dark grey shale ...	13	4	717	9
72	Strong grey post, with a little *limestone* ..	1	4	719	1
73	Strong grey post	29	6	748	7
74	Grey post, with shaly partings	5	8	754	3
75	Strong grey post	15	10	770	1
76	Strong grey post, with shaly partings	48	2	818	3
77	Grey shale and ironstone-balls	19	3	837	6
78	*Limestone*, blue, with shells ...	7	2	844	8
79	Grey post ...	13	11	858	7
80	Grey post and shale	8	4	866	11
81	Dark grey shale ...	3	5	870	4
82	Grey post and shaly partings	5	2	875	6
83	Soft dark grey shale	1	7	877	1
84	Strong grey post	39	3	916	4
85	Grey shale ...	8	10	925	2
86	Grey post and shaly partings	25	6	950	8
87	Grey shale ...	4	6	955	2
88	Grey post ...	2	0	957	2
89	Dark grey shale	12	6	969	8
90	Grey post, with shaly partings	9	9	979	5
91	Dark grey shale, with iron-pyrites	18	11	998	4
92	*Limestone*, blue, **A**	12	2	1,010	6
93	Grey post, with shaly partings	5	5	1,015	11
94	Grey shale, with post-girdles ...	17	8	1,033	7
95	Hard grey post and shaly partings	20	2	1,053	9
96	**COAL**	0	4	1,054	1
97	Grey post ...	1	3	1,055	4
98	Grey shale, with pyrites ...	22	3	1,077	7
99	*Limestone*, blue	6	10	1,084	5
100	Dark grey shale	13	6	1,097	11
101	*Limestone*, blue, **B**	50	2	1,148	1
102	Dark grey post	1	4	1,149	5
103	Grey shale and pyrites ...	1	1	1,150	6
104	Gannister ...	1	0	1,151	6
105	Grey post, with silica	34	7	1,186	1
106	**COAL**, coarse ...	0	2	1,186	3
107	Dark grey post ...	2	7	1,188	10
108	Very coarse strong post, with thin *coal*-threads ..	54	3	1,243	1
109	Dark grey shale	40	2	1,283	3
110	*Limestone*, blue, **C**	20	2	1,303	5
111	Grey post ...	14	7	1,318	0

The PRESIDENT (Sir Lindsay Wood, Bart.) said that the members were much indebted to Mr. J. B. Simpson for having brought this important matter before them. It was the more important at the present time, as Mr. Simpson pointed to another source of coal-supply, which, in the public mind, was formerly not in existence.

Prof. R. A. S. Redmayne (The University, Birmingham) said that Mr. Simpson's paper was of the greatest interest to mining-engineers, in view of the fact that the Coal Commission was at present engaged in enquiring into the question of the coal resources of the kingdom. He had just returned from the United States of America, and had been interested by the extraordinary depths from which minerals were drawn in that country. Mr. Simpson had mentioned that an extraordinary depth would be 4,000 feet, but at the Tamarack mine they were drawing from a depth of 5,100 feet, and at Trimountain, which was at present 900 feet deep, a winding-engine was in process of being erected to draw from a maximum depth of 6,000 feet. Again, at the Calumet and Hecla mine, the depth of the Red Jacket (vertical) shaft was 4,800 feet. With regard to the Chopwell Woods boring, was it not quite probable that there might be a thickening of the Bernician formation in that district? They knew of such thickenings in other parts of the country, and that formation might very probably thicken as much as 3,000 feet.

Mr. David Burns (Carlisle) said that he might mention one little scrap of comfort in connection with Mr. Simpson's paper, and that was that the beds from about the third or fourth limestone shown in the section illustrating his paper, thickened very much as they went downward. South of the South Tyne river, if a particular bed of limestone were selected and followed in the country to the north of that river, it would be found to break up into several more or less impure limestones, with calcareous sandstones and shales between, giving an aggregate thickness much in excess of the limestone, where first seen to the south, so that if a sinking were made in the county of Durham the Scremerston coal-seams, if present at all, would be found much nearer to the surface than would appear to be the case from the sections measured at the outcrops of the measures. At any rate, this will prove to be so if the beds vary in the east of Northumberland as in the west.

Mr. A. L. Steavenson (Durham) said there was no one in a position to dispute or criticize the paper just read by Mr. Simpson, that gentleman having made the subject peculiarly his own. The paper was a most valuable contribution to the *Transactions*, and would remain for future years a mine of information, not

only about the Chopwell bore-hole, but about all that is known in the district on the subject. Mr. Simpson had said that the question as to these lower seams could only be settled definitely by further borings and sinkings being made in the different districts. This was very likely true, but at the same time he (Mr. Steavenson) would be inclined to look at the outcrops and see if anything could be found out respecting them. The depth of 4,000 feet mentioned by Mr. Simpson in his paper had been arrived at by an investigation of these outcrops; and it would also be useful if he made some reference to the rocks and coal-seams in the neighbourhood of Barnard Castle and Wensleydale.

Mr. John Morison (Cramlington) said that he had listened to Mr. Simpson's paper with the greatest interest, and having had considerable experience in connection with the Mountain Limestone series in Scotland, he agreed with Mr. Simpson's hopeful view that workable coal-seams would be found under the regular Coal-measures in Northumberland and Durham. One single bore-hole, as Mr. Simpson had said, could not be taken as a true guide as to whether workable seams would be found. If the seam was missed in the Chopwell bore-hole, there was a large area still to be investigated, and he thought that there was every probability of workable seams being found at workable depths in south-east Northumberland and possibly in Durham. From the indications, however, he should say that south-east Northumberland would seem a more hopeful field than Durham, because these lower seams had been proved over a large area of outcrops, and seemed to be fairly persistent northward from the river Tyne.

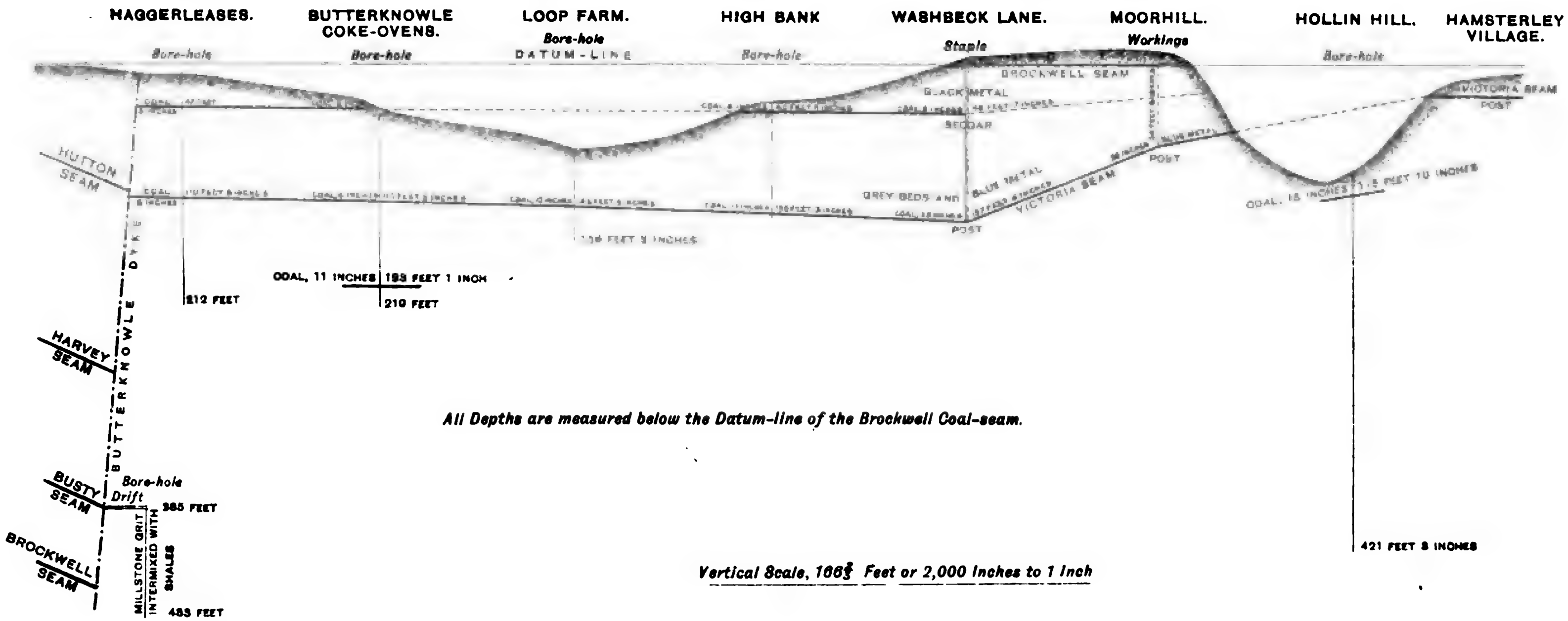
Mr. John Nevin (Mirfield) said that, on comparing the section of the Chopwell bore-hole with Mr. Westgarth Forster's section of the measures, which has been proved to be very correct in the Alston and Allendale districts, with which he (Mr. Nevin) had some acquaintance, he noticed that while Mr. Forster gives the thickness from the Brockwell seam to the first or Fell Top limestone as 509 feet, the Chopwell bore-hole shows 481 feet to the first limestone. If, however, he took the Chopwell limestone, 50 feet thick, the bottom of which is 1,314 feet below the Brockwell seam, as answering to the Great limestone, the bottom of which Mr. Westgarth Foster gives as 979 feet below the Brockwell seam, there is a thickening of the measures of 335 feet or

34 per cent. If this be so, the 4 inches of coal, at a depth of 1,220 feet below the Brockwell seam, would represent the seams between the Great and Little limestones, now worked near Alston and in West Allendale; and the limestone at a depth of 1,176 feet would represent the Little limestone—several limestones having set in between this and the Fell Top limestone. He (Mr. Nevin) suggested that this was the case, and he was afraid that there was not much chance of finding workable coal-seams at a reasonable depth in this neighbourhood. He considered that a bore-hole, say, at Broomhill or Amble, would be more likely to find workable seams in the Limestone-measures.

Mr. J. S. Robson (Butterknowle colliery) wrote that he could not give any reliable information relative to the coal-seams lying below the Brockwell seam, except with regard to the strata lying immediately below the above-named seam in the Butterknowle district. The sections (Plate XX.) only include sections of bore-holes, etc., in which the seams can be correlated, and exclude those others in which the stratigraphical position of the coal-seams does not appear to have been correctly obtained. So far as workable coal is concerned, the Victoria seam is the only one below the Brockwell, found to be of any present value, in this district. This seam is now being explored at Moor Hill, at a depth of 68½ feet below the Brockwell seam. The coal averages 2 feet 6 inches in thickness with one or two irregular bands, ½ to 1 inch thick. At Washbeck Lane, about 4,200 feet south-west of the workings at Moor Hill, a staple has been sunk to the Victoria seam, 137 feet 4 inches below the Brockwell seam, almost exactly twice the depth at Moor Hill. A seam, 11 to 13 inches thick, has been found about 80 feet below the Victoria seam at Hollinhill and the Butterknowle coke-ovens; and explorations to a further depth of about 300 feet, have proved Millstone Grit, with shales, but no coal has been found.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that in the south-western part of Northumberland, the south-eastern and southern parts of Cumberland, in the west of Durham, in Yorkshire, and in Lancashire where the Bernician beds come to the surface and are capable of direct observation without the aid of mining operations, the coal-seams found in this series in the northern parts of Northumberland and Cumber-

To illustrate Mr. J. S. Robson's Notes on "The Strata below the Brockwell Coal-seam at Butterknowle."



All Depths are measured below the Datum-line of the Brockwell Coal-seam.

Vertical Scale, 166⅔ Feet or 2,000 Inches to 1 Inch

land do not exist, or are represented by only a few inches of coal, and this barren condition prevails farther south; while going into Scotland, the Bernician coal-seams increase in thickness. But in south-western Northumberland, in western Durham, in south-eastern and southern Cumberland, in Yorkshire, and in Lancashire, the information obtained by surface-examination is confirmed by the exploration of the beds in mining for ores of lead, zinc and iron. The presumption is therefore that the farther south one goes the less probability there is of finding workable coal-seams in the Bernician beds, and it appears to him (Mr. Atkinson) that the results obtained in the Chopwell bore-hole might have been anticipated.

There seems to be no reason to believe that the Bernician beds may not be productive of coal-seams under the Upper Coal series; this is practically proved to be the case at one or two points in Northumberland and Cumberland, and it is undoubtedly the case in Scotland, although there it has not been proved to the extent that Mr. Simpson supposes, as will be mentioned later. What is the course of the line marking the southern boundary of the productive Bernician beds, he (Mr. Atkinson) could not state, but he thinks that the Chopwell bore-hole may lie to the south of this line.

It appears more probable that workable coal-seams may be found in the Bernician beds underlying the Upper Coal-seams in Northumberland than in Durham, and the farther north one goes in Northumberland the greater is the probability of a favourable boring. Bore-holes through the Upper Coal series, lying north of the Blyth or Wansbeck rivers, would be very likely to pass through workable coal-seams in the Bernician beds, and it is here that the first successful results must be looked for, rather than in the county of Durham.

Mr. Simpson's statement that in Midlothian "the Mountain Limestone formation contains many workable seams" is correct, but he is not quite accurate when he continues "which are sunk to through the regular Coal-measures and Millstone Grit series lying above them." There is only one example of the kind in Midlothian, the Newbattle Victoria pit, which passes through the lower part of the Millstone Grit and is sunk nearly 1,800 feet to one of the lowest seams in the Mountain Limestone. The writer is only aware of one other example of the kind in Scotland: the

Fence pits, near Lesmahagow, in Lanarkshire, passed through the Virtuewell, Kiltongue and Drumgray seams lying in the lower part of the Upper Coal-seams, through the Millstone Grit and down to the Lesmahagow cannel coal-seam in the Mountain Limestone. There can, however, be no reasonable doubt that, in Scotland, large areas of workable coal-seams in the Mountain Limestone underlie the Upper Coal-seams.

Mr. Simpson gives the total estimated production of coal from Mountain Limestone in the North of England as 478,000 tons; and the output in 1887 was:—Northumberland, 332,961 tons; and Cumberland, 50,913 tons.* The comparative production of coal from the various formations in Scotland, in 1892, were:—Oolite, 4,622 tons; Coal-measures, 21,307,081 tons; Millstone Grit, 3,950 tons; Carboniferous Limestone, 5,876,020 tons; Calciferous Sandstone, 250 tons; a total of 27,191,923 tons.†

Mr. M. F. Holliday (Littleburn Colliery) wrote that, at Broompark colliery, the following coal-seams had been found below the Brockwell seam, lying at a depth of 562 feet 4 inches:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.		Depth below the Brockwell Seam. Ft.	Ins.
No. 1	0	3	...	20	6
Victoria	0	8	...	63	0
No more coal proved down to ...	...		...	66	0

He thought that Mr. Simpson was correct in his conclusion—that workable seams will be found below the Brockwell seam. The matter is of vital importance, and all lessors and lessees of mines in Northumberland and Durham should combine, and solve the question by having large bore-holes put down in different parts of the coal-field.

Mr. J. C. B. Hendy (Etherley) wrote that, since the bore-hole was put down at Witton Park in 1834 by Sir William Chaytor, several attempts have been made in the western portion of the Bishop Auckland district to prove and work the coal-seams lying below the Brockwell seam and in the Millstone Grit, but the results so far only appear to shew that these coal-seams are very variable in section and quality.

* "Mining and Quarrying," by Mr. J. B. Atkinson, *British Association, Newcastle-upon-Tyne Meeting, 1889: Official Handbook to the Industries*, page 37.

† "The Mining-fields of Scotland," by Mr. J. B. Atkinson, *Transactions of the Mining Institute of Scotland*, 1893, vol. xiv., page 219.

The Victoria seam has for some time been successfully worked at the Woodifield colliery, near Crook; but taking a line running about south 11 degrees east from that colliery to Witton Park, a distance of about 3 miles, at Woodifield it has a thickness of about 2 feet 6 inches; at Low Beechburn of 1 foot 8 inches; near Witton Junction, it has increased again to 2 feet 6 inches; and at Witton Park, it has again decreased to only 1 foot of coal. On another line, running about south 28 degrees west, from Woodifield to Butterknowle, a distance of nearly 7 miles, the Victoria coal-seam has been proved of the following sections:—Woodifield, 2 feet 6 inches; a little to the west of Hargill Hill, 1 foot 10 inches; near Stonechester, it has been proved to be a little over 2 feet; and at Butterknowle it is about 2 feet 4 inches. It seems probable, therefore, on the greater portion of the latter line, that the Victoria seam may be found of a workable thickness, excepting, of course, where it is denuded in that part which crosses the valley of the river Wear.

The Witton Park bore-hole proved another seam, 2 feet thick, about 48 feet below the Victoria seam, with a band of fire-clay, 1 foot 3 inches thick. This seam has been worked at Marshall Green colliery, but he (Mr. Hendy) was not aware that it had been successfully worked elsewhere in the district.

Another seam, 6 inches thick, has been found a little to the west of Witton-le-Wear, lying at a horizon about 150 feet below the Victoria seam; and this seam may be correlated with the lowest seam mentioned in the Witton Park section. So far as he (Mr. Hendy) was aware no workable coal-seam had been proved in the Millstone Grit series of this district below the last-mentioned seam.

Between Frosterley and Stanhope, a seam of coal, about 2 feet thick, had been found lying about 20 feet above the Fell Top Limestone: it was worked some years ago, but was now abandoned. Mr. Westgarth Forster, in his section of the Weardale measures, only mentioned four other thin seams of coal below the Fell Top Limestone, the thickest of which he gives as 1 foot 6 inches; and it would therefore appear that many of the seams mentioned by Mr. Simpson in his valuable paper, as now being worked in Northumberland, either do not continue or have become much thinner in south-western Durham; and as strengthening this assumption it may be taken as significant that in a recent paper on the Weardale limestone written by

Mr. A. L. Steavenson, whose knowledge and experience of the district is very considerable, no mention is made of any workable coal-seams below the Millstone Grit.*

In estimating the amount of coal likely to be found in the seams of the Millstone Grit and Mountain Limestone, he (Mr. Hendy) thought that it was very essential that the mining-engineer should carefully consider the probable manner in which these coals were formed. It seemed in every way likely that, at the time of the deposition of a group of rocks, the origin and character of which are so eminently marine as the Mountain Limestone, the land-surfaces upon which coal-plants, etc., could flourish would be limited. Speaking of the coal-seams which occur in the Gannister, Sir Charles Lyell remarked that "in some instances the vegetation did not grow where it became mineralized but was carried by water-power from some other locality and deposited."† Other geologists who have studied the character of the coal-seams in the Mountain Limestone have expressed the opinion that some of these seams have evidently been formed from accumulations of sea-weeds, fucoids and other marine plants. He thought that it might be fairly argued that workable coal-seams formed by such actions as those that he had quoted, would be exceptional, and a careful examination of the fossils above, and in, the seams of the Mountain Limestone of Northumberland, would probably yield much interesting information as to the origin of these coal-seams and throw further light on these questions. Whether or not these theories were correct, it certainly appeared evident that the physical conditions prevailing at the time of the formation of the Mountain Limestone coal-seams, were different from those existing when the formation of the seams in the Upper Coal-measures took place, and that they were not so favourable for the dense growth of terrestrial vegetation in the former period as they were in the latter. Mr. Simpson's paper gave abundant proof that there are valuable seams of workable coal in the Mountain Limestone and Millstone Grit, but that they can be relied upon in the north of England to maintain anything like a workable thickness or quality over very considerable areas is, he thought, open to doubt, and more especially does this appear to be so in the south-western district of Durham.

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 115.

† *The Student's Elements of Geology*, fourth edition, 1885, page 361.

Mr. J. B. Simpson, replying to the discussion, said that, no doubt, as Prof. Redmayne and Mr. Nevin had pointed out, there appeared to be a thickening of the formation going eastward and north-eastward. This was shewn also by Prof. G. A. Lebour in his geological map of Northumberland. The Chopwell bore-hole seemed to confirm this opinion, and it passed through what may be considered the representative of the Great Limestone about 335 feet deeper in the formation than shewn by Mr. Westgarth Forster in his section. In the eastern and northern districts, the Great Limestone appeared to occur still deeper in the formation. Mr. Burn's idea that the limestones were more broken up in the eastern portion of the coal-field seemed to be borne out by fact, and there was no doubt that there were more beds of limestone there than in the western district, but not individually of so great a thickness. As to Mr. Steavenson's suggestion that the outcrops of the beds should be more minutely examined, there is a great deal to be ascertained by this investigation being further carried out, although to conclude whether the seams already found in the uncovered Mountain Limestone occur under the regular Coal-measures can only be ascertained by actual borings and sinkings. Probably, as Mr. Morison suggested, there may be more hope in the northern districts. The remarks of Mr. Atkinson and other speakers are very interesting and valuable and tend to throw further light on the subject under consideration. He (Mr. Simpson) might add that a great deal is still to be ascertained and he suggested, to the younger members especially, that they would find a profitable and interesting study to the further investigation of the Mountain Limestone formation. Much had already been written about it by many of the members and others, but its importance becomes almost daily greater if, as the writer ventured to predict, there were workable seams lying under the present coal-field, as they would add many years to the duration of the great northern coal-industry.

The President (Sir Lindsay Wood, Bart.) moved a hearty vote of thanks to Mr. Simpson for his valuable paper.

Mr. M. Walton Brown seconded the resolution, which was cordially approved.

Mr. J. R. Gilchrist read the following description of "Garesfield Railway and Incline":—

GARESFIELD RAILWAY AND INCLINE.

By J. R. GILCHRIST.

The old wagonway was a very zigzag road, with a somewhat light section of rail, and was worked by two standing-engines with drums. It was a single line, the empty wagons being hauled up and the loaded traffic taking the rope down. It was found that this line was quite inadequate, and could not be made suitable for dealing with an increased tonnage, such as was required. The question was therefore considered whether a locomotive line could not be made right through, and various sections were taken over different routes; but it was found that to dispense with a self-acting incline would mean a much more expensive line, seeing that the distance would be almost doubled, and, moreover, it would have necessitated making arrangements with other landowners. It was, therefore, decided to have the self-acting incline as the middle section, and to use locomotives at the top and bottom respectively, conveying the traffic from the collieries to the top of the incline, and from the bottom of the incline to the company's staithes at Derwenthaugh on the river Tyne.

The length of the incline is about 8,700 feet: the bottom is situated near Winlaton Mill, on the northern bank of the river Derwent, and the top is near Garesfield farm. The gradient at the top is 1 in 14, the middle portion 1 in 21, and the bottom portion 1 in 19. The difference in level between the top and the bottom of the incline is 460 feet.

The incline is worked by two drums, A, 15 feet in diameter and 6 feet wide, and both drums are fixed on a shaft, 10 inches in diameter. The drum-house is placed at the junction of the empty-wagon roads, and the views (Figs. 13 and 14) show that the drum-house is elevated above the empty-wagon roads. The top of the drum-house is covered with an iron tank, used as a reservoir to store water for supplying the locomotives. Figs. 1

and 2 (Plate XXI.) shew the arrangements at the top of the incline. There are four sets of roads, the two middle roads in the dish being empty-wagon roads, with two full-wagon roads on either side, elevated on kips.

Approaching the incline-top is a long siding to permit of the locomotive getting round its load. The wagons are pushed upon the two kips, and divided equally between the two sides.

The loaded traffic serves to the rope, and the empty traffic falls into the dish, after being released from the rope. The arrangement of the rails on leaving the top of the incline is also

FIG. 13.—WESTERN FRONT OF DRUM-HOUSE.

shewn in Figs. 1 and 2 (Plate XXI.) and it will be seen that there is a pair of runaway-switches, B and C.

There are two chocks, D and E, and F and G, on each of the full-wagon roads, the loaded trucks remain behind the chock, D or F, and when a set of six wagons is to be got ready, it is lowered down by the attendant between the two chocks D and E or F and G. The rope is then attached to the loaded wagons, the chock, E or G, is opened; and the runaway-switch still being open, when it is found that the rope has got the weight of all the trucks, the runaway-switch, B or C, is closed by means of a small galvanized rope and lever, and the set of wagons is then at liberty

to proceed down the incline. From the top of the incline to meetings, the line consists of three rails, and the three rails joining the four rails at meetings by a V rail, obviate the necessity of points, which would have been indispensable had there only been two rails on the top of the incline-meetings.

From meetings, the four rails are continued to near the bottom of the incline, where there is a short length of single road from this point to the commencement of the full and empty roads (Figs. 3 and 4, Plate XXI.). The switches at the bottom of the incline are weighted, and are worked alternately by the loaded set

Fig. 14.—Eastern Front of Drum-house.

passing over them. At the bottom of the incline, there are also four sets of rails the full-wagon roads being on the low level and the two empty-wagon roads adjoining each other on the high level. This is the reverse of the arrangement at the top of the incline, but it is required in order that, in this case, the empty wagons may serve to the rope.

All the sheaves are made of toughened steel, and the rollers between the rails are 9 inches in diameter by 10½ inches wide (Figs. 5 and 6, Plate XXI.), weigh 45 pounds, and run loose on the spindle. The outside dimensions are 10½ inches wide by 12½ inches in diameter on the flange. They are evenly balanced, and

continue to run for some considerable time after the end of the rope has passed the sheave. At the top and bottom of the incline, there is a curve of 2,640 feet radius, which necessitates the use of angle-curve sheaves (Figs. 7 and 8, Plate XXI.), the spindle in this case being fast. The sheave is $4\frac{3}{4}$ inches wide, $13\frac{3}{8}$ inches in diameter, and weighs 27 pounds.

The curve-sheaves at the left-hand side, on leaving the top of the incline, are placed between the rails; and, under ordinary circumstances, this would have been the same on the other side, but the sheaves are placed, in this case, on the outside of the rails to permit the bringing up or taking down of locomotives without having to remove these sheaves. This removal would otherwise have been imperative, if they had been placed in the middle of the road, as they cannot be set sufficiently low to suit the rope and to leave sufficient height above the rails to clear the works of a locomotive.

As the incline varies from 1 in 14 to 1 in 21, and it was desired to run with not less than six $10\frac{1}{2}$ tons loaded wagons, it was deemed advisable not to rely on a single wheel at the top of the incline, but to provide two drums, of the size already given, with powerful brakes, so that the load would be better under the control of the drum-attendant; and, moreover, should either rope break, in this case, it would not in any way affect the other set, whereas with an ordinary wheel, the one rope is connected to both full and empty sets of wagons, and hence any breakage of either the rope or the attachments of one set would affect both sets. It may be asked why four rails are used from meetings to the bottom, instead of two rails; but by having four rails, any break-away of the loaded set coming down cannot affect the empty set going up. Further, if the line below meetings had been either of two or three rails, any break-away of the loaded set above meetings would of necessity have dashed into the empty load, as the empty load would then have been brought to a standstill, owing to the break-away of the full load. In addition, by having four rails near the bottom of the incline, the attendant, at the bottom, can see whether the switches are, each time, in their proper position; whereas if they had been placed half way up the incline, they might have been interfered with without anyone's knowledge, and thus cause serious breakages.

The sets generally consist of six $10\frac{1}{2}$ tons full and empty

wagons, but the gradient is sufficient for six loaded wagons to haul up five empty and one loaded wagon, or four empty and two loaded wagons, so that there is sufficient margin of power to bring up any loaded traffic that may be required. Occasionally, sets of seven wagons are run, but it is found that six trucks is a safe load, and as much as the attendant at the drums can safely control; but whether the number of wagons to the set be six or seven greatly depends upon the condition of the rails, as in dry weather, seven trucks in a set can be safely taken, though this cannot be ventured when the rails are greasy. There are two brakes to each drum, and the brakes are placed on both sides and around the drums. The brakes are controlled by wheels-and-gearing, and one wheel works the two brakes on the outsides of the drums, the other wheel works the other two brakes on the insides of the drums and, if necessary, the four brakes can be applied together. In the unlikely event of a breakage in the brake-gear of both drums, the attendant at the bottom would bring the set to a standstill by using the runaway switch, and the attendant at the top would also take means to throw the set off the road, by putting the points half-over or by placing some other obstruction on the rails.

The ropes are made of crucible steel, with six strands, and are 3 inches in circumference. One of these ropes was put on to the old wagonway in April, 1897, and was transferred to the new incline in July, 1899. It is still at work, and from all appearances it will last for some considerable time longer.

The method of attaching the rope to the trucks is as follows:—A ⅝ inch chain, A, 6 feet long, is placed over the drawbar, under the body of the last truck, together with a piece of ash timber, B, 4 feet 1½ inches long by 9 inches deep and from 4½ to 5½ inches wide, known as the *devil* (Figs. 9 and 10, Plate XXI.). The devil is slung by two small chains and S links, C, behind the wagon-buffers (or end-stanchions) of the truck; the two loose ends of the ⅝ inch chain, A, are then brought under the devil, and together with the centre-chain, D, the truck is coupled to the rope-end chain, E, by a shackle, bolt and cotter, F. The devil is used on account of there being two curves on the incline. Had the incline been straight throughout, the devil would not have been necessary, as the rope would then have been properly laid upon the rollers. The object of the devil is to guide the rope

upon the curve-sheaves, and to prevent the rope from rising and throwing itself off the sheaves.

At the bottom end of the incline, the rope-end chain is only hung on to the centre-crook of the drawbar of the truck.

On the right-hand drum, the rope leaves from the top side; and on the left-hand drum, from the bottom side; the ropes being placed on the drums so as to be at the outside of the drums, when the empty set is cast off at the top of the incline. This provides for the rope that is lying down the incline being placed as far away from the set that is being landed at the top as possible. Otherwise, if the ropes were cast off at the inside of the drums they would be very near the trucks that have arrived at the top and might be a danger to the attendant in landing the sets.

Where the top rope touches the first two sheaves from the drum, there is a side-movement of the rope of about 3 feet, and instead of using one large drum-roller, over 3 feet long, which would entail considerable friction to make it move round, this roller is made up of 24 small sheaves (Figs. 11 and 12, Plate XXI.). The rope moves from one sheave to another, and each small sheave revolves instead of a long roller, and therefore greatly reduces the friction and also the wear-and-tear. Each of these small sheaves can be replaced separately, instead of, as in the other case, having to replace a long roller. Each sheave is $1\frac{1}{2}$ inches wide, 12 inches in diameter, and weighs 15 pounds. The axle is 2 inches in diameter.

Half-way from the top of the incline to meetings, there is a runaway-switch on either side (not shown in Figs. 1 and 3) worked from the top of the incline by means of a rope attached to a hand-winch. Below this point, there is no further provision until the bottom of the incline is reached, where a runaway-switch is placed on the single and full-wagon road immediately before it reaches the two full-wagon roads, and it is under the control of the attendant at the bottom.

In addition to the attendant at the drums, there is only one attendant at the top of the incline and one at the bottom, so that in all three hands are employed, together with one boy employed in oiling the sheaves.

The time occupied in completing a run, including the time spent in making the set ready at the top and the bottom, varies from 15 to 17 minutes, of which 7 to 8 minutes are occupied in the

running from start to finish ; and when the sets are in full run the speed ranges from 20 to 25 miles an hour. Under ordi conditions, 4 sets are run in an hour, equal to 24 trucks, or tons of coal per hour ; but with an additional workman at the and the bottom this quantity could be considerably increased, 6 sets have actually been run per hour, that is, 36 trucks, or tons of coal. There would be no difficulty in running 3,000 in an ordinary day of 10 hours working.

Since the incline commenced running 2½ years ago, there not been the slightest accident in its working, and it has fully all requirements.

Mr. P. Kirkup (Birtley) asked, with regard to the applia described as the "devil," whether this was used to keep down rope and make it strike into the sheaves when going round cur

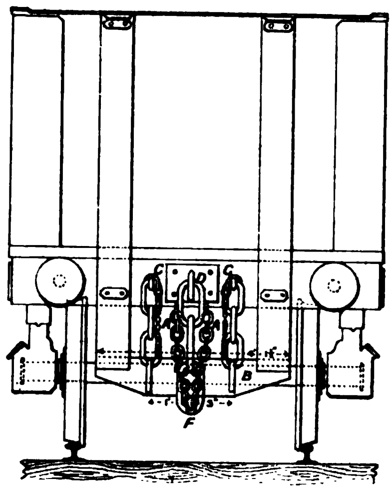
Mr. J. R. Gilchrist said that it was so used.

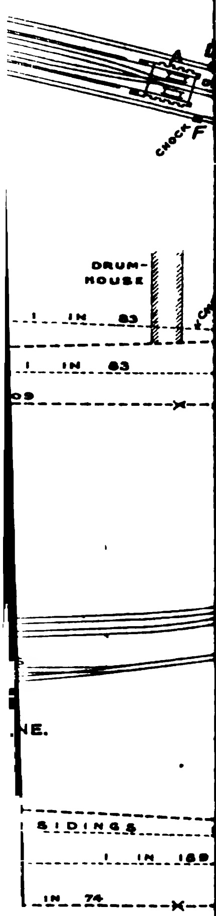
Mr. Henry Lawrence (Newcastle-upon-Tyne) remarked th the application of a series of rollers, instead of having one on was not new, but the system of oiling was original: one hollo fixed spindle went through the whole of the rollers which turn round on it; and opposite the centre of each roller was an oi hole, so that it was self-oiling.

Mr. J. D. Twinberrow (Newcastle-upon-Tyne) wrote that h was gratified to find that the incline and the drums for working it had hitherto met all requirements, more particularly since the responsibility for the design of the machinery rested with Mr. G. H. Sheffield and himself, and they had not hesitated to introduce features which might be considered to be of a somewhat experimental nature. He appended some particulars in tabular form, showing the general specification, with an estimate of the stresses on the rope and of the speed of working. It will be noted that the load hauled in daily work is in excess of that originally contemplated; it is also apparent that the auxiliary power might be dispensed with under all ordinary conditions of weather and traffic; and he believed that no delay had arisen owing to the absence of the steam-power for which provision had been made in the designs. He considered that any excessive weight in the drums was very undesirable, because an increase in the mass of the moving parts prolonged the period during which acceleration

on "Garesf

FIG. 9.—METHOD OF ATTACHING THE ROPES TO THE TRUCK.





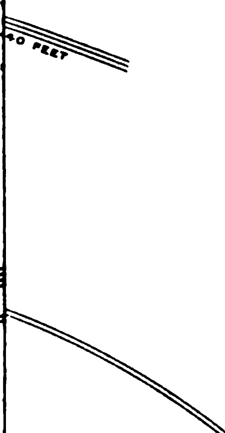
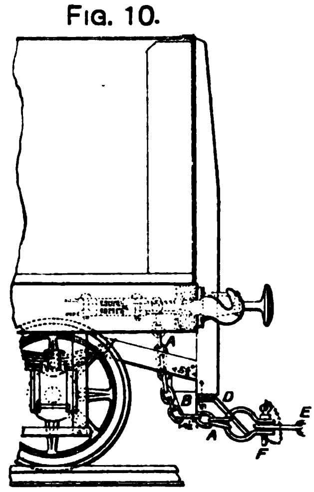
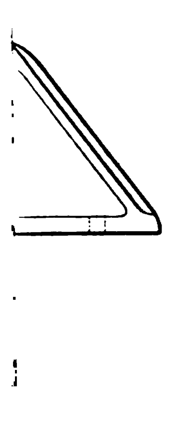


FIG. 10.



Scale, 4 Feet to 1 Inch.

E SHEAVE.



SHEAVES.

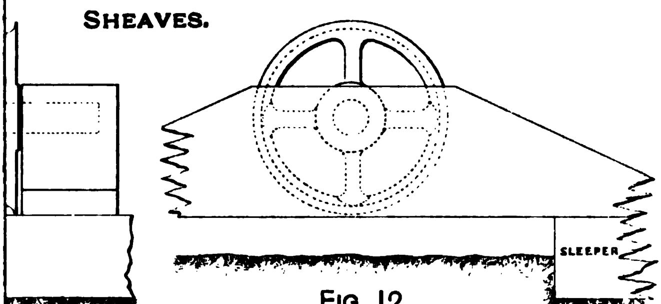


FIG. 12

Scale, 1 Foot to 1 Inch.

was taking place, and it also required a larger axle with a greater weight on the bearings, thus increasing the moment of the frictional resistance. The drums were accordingly made entirely of steel, each drum had two cast-steel bosses, halved upon the axle, each boss carried eight radial arms of bulb T section, plated flush outside and braced transversely by L bars. The radial arms supported the brake-races and shill-boards, which were segmental castings of steel having an inwardly projecting flange to which the rim-plates were rivetted. The plates are not otherwise stiffened or supported, as they are designed to resist the cumulative stresses due to the superimposed coils of rope, which are laid on under the maximum tension, purely by circumferential compression. The band-brakes are applied in independent pairs, but each pair has one band on each drum, so that the retardation is applied to both drums under all circumstances.

The running speed appeared to be considerably higher than that customary in self-acting inclines: this was an indication of the excellent character of the permanent way and of the skilful manner in which Mr. Gilchrist had arranged the guide-sheaves and provided for hooking on and casting off the sets on a practical and safe system. He would be glad to know whether Mr. Gilchrist found that bull-headed rails in cast-iron chairs were preferable to flange-rails for roads of this description: it occurred to him that the corrosion, set up by cinder-ballast in contact with the thin flanges, would be an objection to the latter type. The action of this class of ballast was very destructive to the floors of steel-bridges, and it was a good practice to replace it with broken stone or other non-corrosive material, for a length of several yards on each side of such bridges. Cinder-ballast was considered moreover to be bad for the ropes, which were liable to pick up gritty matter therefrom. Local conditions were naturally of paramount importance in determining the laying-out of an incline-railway; but, speaking generally, the most economical solution of the problem of connecting two railways at different levels would be found in continuing the adhesion-roads as far as possible up the valley and along the hill-side respectively, and in making the incline as direct and short as possible, as the only practical limit to the gradient was that at which the loads were liable to be shifted by the inclination of the cars.

It appeared that the working of points and signals at long distances by means of electric or pneumatic power would lead to an economy in the cost of these railways, as a single line with a passing-place would meet requirements if the points were controlled with absolute certainty from the brakesman's cabin; runaway switches could be worked by similar means, and the provision of a simple interlocking gear would ensure the correct working of the points for the respective sets.

General Specification.—The working of the incline shall be self-acting, and each set of 5 laden wagons shall draw up 5 empty wagons.

Two drums shall be fixed upon a single axle, a separate rope shall be provided for each drum; and the ropes shall be coiled on the drums in opposite directions. The diameter and width of the drum shall be such that the entire length of rope may be wound up in not more than 3 complete coils. The internal width of the drum-house shall not exceed 25 feet.

The running speed shall not exceed 20½ miles per hour, say 30 feet per second. The machinery shall be capable of lowering 3,000 tons per working-day. An auxiliary engine shall be geared at will to the drums for the purpose of drawing up a laden wagon.

NOTE.—The addition of a laden wagon involves an average increase of 20 cwts. in the resistance up the incline, and the maximum speed of the drums is 39 revolutions per minute. Therefore, the engine, when geared at 6 to 1, makes 234 revolutions per minute.

In order that the engine may exert a tractive force of 20 cwts., at any speed, it must be capable of indicating 153 horsepower at the above speed, because 20 cwts. at 30 feet per second is equal to 122 horsepower, and the efficiency of the engine and gearing may be taken at 80 per cent.

Weight to be moved:—

	Tons.	Cwts.
10 wagons at 6 tons 6 cwts. each	63	0
5 loads of coal at 10 tons 10 cwts. each	52	10
6,100 yards of rope at 6 pounds per yard	16	6
2 drums of 15 tons each, referred to their radius of gyration: – W × rad. + R	27	0
	158	16

Tension on Rope:—

	Tons.	Cwts.	Tons.	Cwts.
5 loaded wagons on incline of 1 in 15 ...			5	12
5 empty wagons on incline of 1 in 94 ...	1	11		
Weight of rope	0	9		
Tractive resistance...	0	14½		
Friction of ropes and machinery... ...	0	10½		
			3	5
Net tractive force			2	7
Net tractive force, with laden wagon added			1	7

Time per Journey.—A tractive force of 2 tons 7 cwts. acting on a mass of 158 tons 16 cwts., produces an acceleration of 0·5 feet-second per second. The time required to attain the working speed is (30 × 1 ÷ 0·5 =) 60 seconds. The distance travelled during acceleration is (½ × 0·5 × 60 seconds =) 900 feet; the remaining distance of 8,070 feet is traversed in 269 seconds; and adding 11 seconds for stopping, the total time of the journey is 340 seconds, or 5 minutes 40 seconds.

When a laden wagon is added, the journey may be completed without the aid of the engine in the following time:—A tractive force of 1 ton 7 cwts. acting on a mass of 175 tons produces an acceleration of 0·248 feet-second per second. The time required to attain the working speed is (30 × 1 ÷ 0·248 =) 121 seconds. The distance travelled during acceleration is (½ × 0·248 × 121 seconds =) 1,815 feet; the remaining distance of 7,155 feet is traversed in 238·5 seconds; and adding 11½ seconds for stopping, the total time on the journey is 371 seconds or 6 minutes 11 seconds.

The speed shall be controlled by the application of the brakes, so soon as the maximum velocity is attained.

Mr. J. R. Gilchrist, replying to the discussion, said that he preferred bull-headed rails and cast-iron chains to flanged rails, because they were less liable to corrosion from cinder-ballast and further that the gauge of the way could be better maintained. With good permanent way there was less liability to derailment of the wagons, and as there had not been a derailed wagon since the starting of the incline, that was sufficient evidence of the character and condition of the permanent way. Cinder-ballast was no doubt detrimental to rails and chairs, but, with ordinary attention, the ballast could be kept from coming into contact with them. The ballast should not be allowed to rise above the top of the sleepers and the space below the rails and between the sleepers should be kept clear. The ropes did not suffer from the cinder-ballast as the ballast was kept below the level of the tops of the sleepers and the sheaves being spaced at the requisite distances apart the ropes never came into contact with the ballast. Cinder-ballast is very suitable for railways because it makes an elastic bed for the sleepers; and as it is a waste-product from collieries, it could not be put to better use than in ballasting the railways. The adhesion roads were continued at the top and bottom of the incline as far as possible, so as to give the shortest practicable length to the incline at Garesfield, and this rule should be enforced in all cases. The working of the points and run-away switches could hardly be left in the case of the Garesfield incline to the brakesman, who had already sufficient work to occupy his attention. It was, however, a question for discussion as to

whether a single line with a pass-bye, and similar arrangements as existed at Garesfield was the most economical, all things being considered, as with the former arrangement the labour-cost would be greater, but the actual laying out and working must be left for decision in each individual case. He (Mr. Gilchrist) did not claim anything new or novel in the series of small sheaves used instead of one long roller and his paper was simply a description of what was used in actual practice.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Gilchrist for his valuable paper.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

A paper was read by MR. H. HUMPHRIS on the "Driving of an Inclined Tunnel 496 yards long and a Tunnel 842 yards long; and a Description of a New Method of Slate-quarrying in North Wales."

MR. DAVID BURNS read a paper on "The Correlation of the Beds of the Carboniferous Series in the North-east and North-west of England."

A paper was read by MR. JOHN KIRSOPP, jun., on "Coal-shipment and the Laying-out of Staithe-heads."

Mr. THOMAS DOUGLAS (Darlington) moved a vote of thanks to Mr. J. S. Dixon for presiding over a section of the meeting.

Mr. H. C. PEAKE (Walsall) seconded the resolution, which was cordially approved.

Mr. ARTHUR SOPWITH (Cannock Chase) moved a vote of thanks to the North of England Institute of Mining and Mechanical Engineers for the great trouble that they had taken in connection with the arrangements of the meeting, for the intellectual food provided for their edification, and for the entertainment, visits to works and collieries, etc., which they were soon to enjoy.

Prof. REDMAYNE (The University, Birmingham) seconded the resolution, which was cordially approved.

Sir LINDSAY WOOD, Bart., returned thanks on behalf of the North of England Institute of Mining and Mechanical Engineers.

Mr. N. R. GRIFFITH moved a vote of thanks to the President (Sir Lindsay Wood, Bart.) for his services in the chair. He remembered Sir Lindsay presiding at a meeting of the North of England Institute of Mining and Mechanical Engineers held in London some 26 years ago; he had not seen much of him in the interval, but he had found him as efficient in Newcastle-upon-Tyne as when he occupied the chair at their meeting in Great George Street.

Mr. J. G. WEEKS seconded the resolution, which was carried with acclamation.

The PRESIDENT (Sir Lindsay Wood, Bart.) said that he was much obliged to the members for their appreciation of his services.

The following notes record some of the features of interest seen by visitors to collieries, works, etc., which were, by kind permission of the owners, open for inspection during the course of the Newcastle-upon-Tyne meeting on September 16th, 17th, 18th and 19th, 1902:—

"NEWCASTLE CHRONICLE."

The members visited the printing works of the *Newcastle Daily Chronicle*, and were shown the details of the production of the special edition of the *Evening Chronicle*, including the operating of the linotype machines, and printing, folding, despatching, etc., of the paper.

WEST SLEEKBURN COLLIERY.

West Sleekburn colliery is one of a group of four collieries belonging to the Bedlington Coal Company, Limited. It is situated in the parish of Bedlington, about 3 miles north-west of Blyth and about 16 miles from the river Tyne.

There are two pits, the downcast shaft being 15½ feet, and the upcast shaft 9 feet in diameter.

Furnace-ventilation, which prevailed from 1862 to 1901, had so corroded the tubbing that in 1898 it was found imperative to reline the upcast shaft with new tubbing, and in so doing to reduce its diameter from 9 feet to 8½ feet for a length of 220 feet. This, in its turn, necessitated the removal of the upper set of lifting-pumps from this shaft, and its being placed in the downcast shaft, and the employment of a mechanical ventilator, so as to avoid the danger of further corrosion and to increase the air-current of the mine.

Three seams of coal are being worked, namely:—

	Thickness. Ft.	In.	Depth at Shaft. Feet.
Yard Seam	2	9	498
Bensham Seam	2	6	612
Low Main Seam	5	0	696

The output is a little over 800 tons per day, and affords employment to 670 men and boys on the surface and underground.

The system of working is bord-and-pillar in the Low Main seam and chiefly longwall in the other seams.

The seams have a rise to the south-west of about 1½ inches per yard. There is a dip-fault to the north of about 636 feet on the extreme northern boundary.

The winding-engine is of the type that in 1862 found general favour in the north, namely:—A vertical cylinder, 52 inches in diameter by 6 feet stroke, with a drum, 19 feet in diameter.

The pumping-engine has a vertical cylinder, 64 inches in diameter by 7 feet stroke, with a cast-iron beam weighing 40 tons. On the western end of the beam is a lifting and a forcing set. The bottom set of pumps, 18 inches in diameter and 7 feet stroke in the pit, lifts from the Low Main seam standage, 336 feet to the mid-shaft standage drift; and from this point to the surface, a ram-set, 18 inches in diameter and 7 feet stroke, forces a height of 402 feet to bank, the rising main being made of steel pipes, 17 inches in diameter, with cast-steel flanges, rivetted to the pipes. The eastern end of the beam carries a balanceweight of 12 tons.

The fan is driven by a compound tandem engine, fitted with Corliss valve-gear, the high- and low-pressure cylinders being 13 inches and 24 inches respectively in diameter by 36 inches stroke. Steam is supplied at a pressure of 100 pounds per square inch.

The governor is cutting-off so as to maintain at a speed of 50 revolutions per minute, a fan of Waddle type, 35 feet in diameter, producing 130,000 cubic feet of air per minute at a water-gauge of 1·70 inches, and 65 indicated horsepower. The fan-drift has an area of 132 square feet.

The electric-lighting plant consists of a trip-gear engine, with a cylinder 10½ inches in diameter by 22 inches stroke, supplied with steam at a pressure of 100 pounds per square inch. It runs at 90 revolutions per minute and drives a compound-wound dynamo supplying 100 ampères at a pressure of 220 volts, equal to 360 lamps of 16 candlepower.

The endless-rope hauling-engine at bank, with a cylinder 14 inches in diameter by 3 feet stroke, is geared 8 to 1. The main-and-tail-rope hauling-engine, with 2 cylinders, 20 inches in diameter by 4 feet stroke, is geared 2 to 1, and is fitted with drums, 8 feet and 7 feet in diameter, running loose on the shaft.

There are 8 Lancashire boilers, 7½ feet in diameter and 30 feet long, working at a pressure of 45 pounds per square inch; and 2 Lancashire boilers, 8½ feet in diameter and 30 feet long, working at a pressure of 120 pounds per square inch. The steam-pipes and some of the boilers are covered with asbestos silicate-cotton or slag-wool.

The screening-plant consists of 2 belt-screens, 4½ feet wide and 50 feet long, with lowering-ends worked by machinery; 2 nut-belts, 4½ feet wide and 57 feet long, and 3 feet wide and 38 feet long, and a small-coal or duff-belt, 3 feet wide and 63 feet long. The shaking-screens and belts are driven by a high-pressure engine, with a cylinder 13 inches in diameter and 24 inches stroke.

CAMBOIS COLLIERY.

Cambois colliery, owned by the Cowpen Coal Company, Limited, is situated on the sea-coast, 2¼ miles north of the town of Blyth.

There are two pits sunk on the royalty, 75 feet apart. The downcast and winding shaft, 15½ feet in diameter, contains pumps, steam-pipes and electric cables. The upcast and ventilating shaft, 14 feet in diameter, is used as a relief shaft, in case of an accident happening to the downcast shaft.

The Low Main seam is worked at a depth of 636 feet and the Yard seam at 435 feet; and the coal from the Yard seam is run down a drift, 1,560 feet in length with a gradient of 1 in 12, to the level of the Low Main seam.

The Low Main seam, with an average section of 5 feet, is worked by the bord-and-wall system, and the workings extend 8,000 feet under the North Sea.

The Yard seam, with an average section of 2⅔ feet, is worked by the longwall system: all the coal is removed, and the engine-planes are made in packed roads.

The vertical condensing winding-engine, built about 1863, has a cylinder 65½ inches in diameter and 7 feet stroke, with a rope-drum, 22 feet in diameter. Steam is supplied at a pressure of 20 pounds per square inch. The pulleys are 16 feet in diameter. Plough-steel ropes, 4½ inches in circumference, are used. The weight of the cages and ropes is counterbalanced by an iron-wire balance-rope of the same size as the winding-rope, attached to the bottom of the cages and running in a groove (without a wheel) in the bottom scaffold. Four tubs, each carrying 13 cwts. of coal, 2 tubs on a deck, are raised at a lift.

The haulage is on the main-and-tail rope system, worked by three Fowler semi-portable engines. Two of the hauling-engines have cylinders 14 inches in diameter, and the third has cylinders 12 inches in diameter, and all of 14 inches stroke, and geared 3 to 1. Steam is supplied at a pressure of 70 pounds per square inch. The steam is brought down the shaft by a range of wrought-iron pipes, 9 inches in diameter, secured by steel-channel collarings, every 15 feet, and fitted with three expansion-joints in the range. Thirty-eight tubs are run in a set in the Low Main seam, and 28 in the Yard seam. The haulage-ropes are made of improved steel, 2½ inches in circumference. The average distance hauled is about 6,000 feet from seven landings, the farthest being 8,700 feet, and the nearest 3,120 feet.

The ventilation of 150,000 cubic feet per minute at 1 inch of water-gauge is produced by means of a furnace, with a fire-grate area of 126 square feet, burning duff and refuse-coal.

The horizontal pumping-engine, placed at the bottom of the downcast shaft, has 2 cylinders each 22 inches in diameter, and 2 ram-pumps, 9 inches in diameter, all of 5 feet stroke, and is capable of dealing with 400 gallons of water per minute.

The heapstead is carried on cast-iron columns with rolled-iron girders, and is covered and roofed with corrugated iron. The screening-plant is capable of dealing with 1,500 tons of coal per day. It comprizes three jigging-screens and picking-belts, and one small coal-belt. Each screen is arranged so that, by altering a trap in the small-coal hopper, the small coal can be diverted on to the main picking-belts should unscreened coal be required. The picking-belts are 75 feet long and 4 feet wide, and travel at the rate of 75 feet per minute. The full tubs are conveyed from the weighing-table to the tipplers by creeper-chains, and after teaming are raised by steam-lifts, which in ascending turn a quarter revolution to the level necessary to enable the tubs to gravitate back to the shaft. The coal, from the tipplers, falls on to spreading belts rising 1 in 7½ to the jigger-screens. The whole of the screening-plant is driven by an horizontal engine, fitted with automatic expansion-gear, with a cylinder 12½ inches in diameter and 26 inches stroke.

Steam is generated in 7 Lancashire boilers, 28 feet long and 8 feet in diameter, working at a pressure of 100 pounds per square inch; and 5 Lancashire boilers, 28 feet long and 7 feet in diameter at 45 pounds per square inch. All the boilers are fired with washed duff coal. The high-pressure steam is reduced to suit requirements by being passed through reducing valves.

The electric-power plant consists of a 40 units dynamo, driven by an horizontal engine, with a cylinder 13½ inches in diameter and 30 inches stroke, supplied with steam at a pressure of 80 pounds per square inch. The current is conveyed to 6 pumps underground, situated at distances varying from 4,500 to 7,500 feet from the generating-station. Each pump is driven by a 6 horsepower motor. The shaft-cables, with 19 wires of No. 13 Birmingham wire-gauge, have a resistance of 4,000 megohms; and the underground cables range from 19 wires of No. 14 wire-gauge to 7 wires of No. 17 gauge, with a resistance of 2,000 megohms. The steam for this engine is generated in a locomotive type of boiler at the power-station. An Arons wattmeter is fixed in the engine-house on the main cable, in order that the output of the dynamo may be continuously recorded. This plant has been in continuous use for the last 8 years.

The under-clay and blue-shale, sent out of the mine, is manufactured into bricks by a machine with an output of 10,000 bricks

a day. The machine is driven by an engine, similar to that driving the screening-plant, and takes its steam from the main boilers. The bricks are burnt in ordinary kilns, each holding 8,000 bricks.

About 300 tons of small coal per day can be treated in the coal-washing plant, which consists of an elevator with stamped-steel buckets, a Robinson washer, and two revolving duff-riddles, each 13 feet long and 4 feet in diameter, with a gauze of $\frac{3}{16}$ inch mesh, all driven with chain-drives by an engine of the same dimensions as that working the screening-plant. When nut coal is being made, the duff, taken from it, can be washed at the same time.

A private railway, 2 miles in length, connects the colliery with the Cowpen Coal Company, Limited's staithes on the river Blyth. There are two shipping-staithes, with two spouts each. The west staithe is 40 feet, and the east staithe 36 feet, above high-water mark, and there is a depth of 24 feet at low-water at each. The east staithe is fitted with an anti-breakage apparatus, which has received the approval of the Admiralty. It consists of a box, holding 2½ tons of coal, made in halves and hinged at the top, and slung to a crane. When full, the weight of the coal carries the box to the bottom of the hold of the ship; there, the catch holding the halves together is released, and the coal is deposited in the bottom; the box then closes automatically and is drawn again into position for loading by means of counterbalance-weights on the crane. This operation is continued until a cone is formed, with its top level with the hatchway, the box is then housed and the loading continued in the ordinary manner. One of Messrs. Bordes' four-masted sailing-ships, taking 3,800 tons of coal to Valparaiso, was recently loaded with this apparatus.

THE IMPROVEMENT OF BLYTH HARBOUR.

Blyth harbour, situate about the centre of the Northumberland coal-field, is the natural port of shipment for upwards of 40 collieries. Although coals have been shipped at the mouth of the river for upwards of 600 years, it is only during the last 20 years that Blyth has risen to prominence as a coaling-port. From 1813 to 1867, the harbour consisted of a short length of

the river-channel, nearly dry at low water, having a few small coaling-staithes on the south side, and a ballast-quay on the north side. The sea-channel of the river Blyth runs south-south-eastward, following approximately a line of fault in the rocks which form an extensive reef, dry at low water, upon its eastern side.

In 1856, a pier, consisting of timber-framing, enclosing a hearting of rubble-stone, was built upon this reef; and on the west side of the channel a training jetty of timber was constructed. At this time, the channel, although dredged to a depth of 4 feet at low water, was shoaled by every storm to about low-water level. In 1867, two coaling-staithes were opened at the north side and a depth was dredged alongside sufficient for vessels of 1,200 tons.

This condition of the harbour obtained until 1881, when the Blyth Harbour Commissioners, in conjunction with the North-eastern Railway Company, constructed two coaling-staithes at the south side. In 1885, a new west pier was constructed to protect the channel from shoaling upon that side, and the east pier was extended in solid concrete. In 1887, a new entrance-channel, having a depth of 10 feet at low water, was dredged about 210 feet to the west of the old channel, thus clearing a reef of rocks, which extended on the line of the old channel for 1,500 feet outside of the pier-head, the great cost of removing which would have made it impracticable to provide a deep-water channel upon the old line. In 1888, two additional coaling-staithes were constructed at the south side of the harbour. In 1896, the harbour was enlarged and deepened, and four additional coaling-staithes were constructed on the north side. In 1898, the entrance-channel was widened, and deepened to 16 feet at low water. In 1899, a new south harbour of 25 acres in area was completed, having a depth varying from 30 to 38½ feet at high water, with wharves, cranes and railway-connections.

The following is a summary of the improvement of the harbour during the last 20 years:—In 1882, the harbour-area was about 25 acres and, except at the Cambois staithes, was practically dry at low water; it could not accommodate more than about 40 small sailing-vessels, while the channel to sea was frequently shoaled to about low-water level.

At the present time, the area of the harbour is about 83 acres, the depth varies from 22½ to 38½ feet at high water, and it is

capable of accommodating over 100 large steamships, and ships up to 10,000 tons capacity have used the harbour. The sea-channel has a depth of 15 to 16 feet at low water, and is capable of being deepened to 20 feet.

The following shews the increase in the coal-shipments:—

	Tons.		Tons.
1883	146,264	1893	2,342,020
1884	362,879	1894	2,643,778
1885	526,667	1895	2,534,558
1886	561,749	1896	2,506,916
1887	585,484	1897	2,722,024
1888	1,018,335	1898	3,033,976
1889	1,263,327	1899	3,297,596
1890	1,715,406	1900	3,318,010
1891	2,047,480	1901	3,230,885
1892	2,157,140	1902	3,279,350

In addition to coal-shipments there is a considerable import-trade in timber. There is also an extensive shipyard, and five large graving-docks at the port.

The chief improvements at present in progress are the widening of the entrance-channel, by two steam-hopper dredgers, and the reconstruction of the old east pier, by enclosing it in concrete.

SEGHILL COLLIERY.

The output of about 1,580 tons of coal per day is drawn from two shafts.

The colliery is ventilated by an open-running fan, 35 feet in diameter, driven by a Corliss engine with a cylinder 16 inches in diameter by 3 feet stroke, fitted with sugar-tong-clip valve-gear. The engine is controlled by a governor, which varies automatically the cut-off and maintains a regular speed, even when the steam-pressure varies. The speed is readily altered by changing the weights placed on the governor, and this can be easily effected while the engine is running. The results of experiments, at speeds of 40 and 60 revolutions per minute, are recorded in the following table:—

No. of Revolutions of Fan per Minute.	Volume of Air per Minute.	Water-gauge.	Indicated Power of Engine.	Useful Effect
	Cubic Feet.	Inches.	Horsepower.	Per Cent.
40	133,952	1·00	42·93	49·17
60	205,932	2·15	133·94	52·09

A vertical engine, with a cylinder 9½ inches in diameter and 9 inches stroke, running at 200 revolutions per minute, drives a dynamo of 15 horsepower. The current is conveyed to a motor of 10 horsepower placed in the Low Main seam, driving a three-throw ram-pump, delivering 100 gallons of water per minute against a vertical head of 120 feet.

The main-and-tail-rope haulage is worked by an horizontal engine, with a cylinder 13½ inches in diameter by 30 inches stroke, fitted with valve-gear controlled by a governor, which automatically varies the cut-off and maintains a constant speed. The speed can be varied between 70 and 100 revolutions per minute by altering a spring attached to the governor, and this can be done while the engine is running. When not employed in hauling, the tail-rope drum can be put out of gear, and a clip-wheel put into gear; and the power is then transmitted by means of an endless wire-rope to the main differential ram-pump placed in the Low Main seam, and forces the water to the surface.

Two similar engines work the endless-rope haulage in the Blake and Yard seams, with 10½ and 7⅓ miles of rope respectively. The shop-engine has a cylinder 10½ inches in diameter and 22 inches stroke.

An engine, with a cylinder 10½ inches in diameter and 22 inches stroke, works the screens, including 4 shakers, 4 bar-belts for best coal, 45 feet long, with lowering arms; 2 belts for small coal; 1 duff-coal creeper; 3 tub-creepers; and 4 kick-ups. These are erected in an iron building with H girder steel legs.

All the engines are supplied with steam at a pressure of 100 pounds per square inch, except two old vertical condensing winding-engines, with cylinders 33 and 34 inches in diameter respectively, for which the pressure is reduced to 40 pounds per square inch. All steam is superheated. There is one range of 5 Lancashire boilers, 8 feet in diameter and 30 feet long. The pit and shops are worked by 3 boilers, mechanically fired with small-coal, mixed with some rough nuts.

The gas-works comprize 9 fire-clay retorts and two gas-holders.

MESSRS. LOCKE BLACKETT AND COMPANY, LIMITED: LEAD-WORKS.

In producing white-lead by the old Dutch stack-process, the metallic lead is cast into thin plates and placed upon earthenware pots containing dilute acetic acid, which in turn rest upon a layer of spent oak-bark; boards are placed above the lead, and other layers of bark, pots, lead and boards, are placed in the stacks until the stacks are full. After a period of about 3 months, the material is removed from the stacks, and a considerable proportion of the metallic lead is found to have been converted into hydrated carbonate of lead. This is crushed, washed, ground and dried, and then becomes the "genuine dry white-lead" of commerce. For painters' requirements, it is ground in refined linseed oil.

CONSETT IRON-WORKS, CONSETT.

Coal and Coke.

The Consett Iron Company, Limited, at the present time, own eleven collieries, extending over an area of 13,000 acres, and producing annually about 1,500,000 tons of coal. There are about 1,050 coke-ovens, producing about 600,000 tons of coke per annum. The greater proportion of the coke is consumed at the company's blast-furnaces, and the remainder is sold for use in blast-furnaces, etc., in Cumberland, Cleveland, and foreign pig-iron producing districts.

Pig-iron.

Blast-furnaces.—The 7 blast-furnaces are each 55 feet high, with a hearth 9 feet in diameter; height to top of bosh, 20 feet; diameter of the bosh, 20 feet; diameter of the throat, 14½ feet; and a bell with an opening of 10½ feet. There are seven tuyeres to each furnace. All the furnaces are fed with material by means of a bell and hopper, with a standard beam and hydraulic brake. The ore and other material for the furnaces is conveyed on a high-level approach, considerably above the tops of the furnaces, in bottom-door trucks, and is tipped from these into depôts, from which the charging barrows are filled.

Each of the furnaces is equipped with three Cowper stoves, varying from 65 to 90 feet in height, and from 21 to 24 feet in diameter.

The pressure of blast, now maintained, is 5 pounds per square inch, and its temperature on entering the furnace is about 1,200° Fahr. At the present time, six furnaces are in blast, and the seventh one is being relined. The six furnaces are making Bessemer pig-iron from imported Spanish and other ores, and produce on an average 750 tons per furnace per week. The limestone comes from the Consett Iron Company's quarries at Stanhope-in-Weardale.

The blowing engines are either of the beam or the vertical tandem type. There are six beam-engines, and two, being obsolete, will shortly be removed. The remaining four engines of this class have steam-cylinders, 50 inches in diameter; and blowing-cylinders, 100 inches in diameter, by 9 feet stroke, designed for a blast-pressure of 5 pounds per square inch. The two vertical tandem engines have steam-cylinders 50 inches in diameter; and blowing-cylinders, 100 inches in diameter, by 5 feet stroke, designed for a working pressure of 10 pounds, and in case of emergency will work to 15 pounds per square inch. They are fitted with Wheelock steam-valve gear and Adamson expansion-governors.

The steam required for driving the blowing-engines, etc., is raised in 19 double egg-ended boilers, each consisting of two lengths, 35 feet long by 4½ feet in diameter; and 12 double tubular boilers, each 31½ feet long, six of which are 7 feet in diameter, and the remainder 7½ feet in diameter. At the present time, three blocks of two boilers are being erected, each of the Babcock-Wilcox water-tube type, capable of working to a pressure of 160 pounds per square inch. The waste-gases from the stoves and boilers pass through a large underground flue to a fire-brick chimney, 250 feet high and 16½ feet in internal diameter, at the top.

The slag from the furnaces is removed in side-tipping ladles, with a capacity of 10 tons.

Engines and Brush dynamos, which generate the energy for lighting the works, are placed in Nos. 1 and 4 blowing-engine houses.

Steel Plates.

There are two melting-shops supplying ingots for the manufacture of steel plates. In the east shop, there is a range of nine Siemens open-hearth furnaces, six of 35 tons capacity, and

three of 28 tons. In the west shop, there are eleven similar furnaces, nine of 20 tons capacity, one of 28 tons and one of 35 tons. These furnaces are supplied with gas from a range of 33 steam-blown Siemens gas-producers. The two melting-shops produce about 4,200 tons of ingots per week.

The No. 2 cogging-mill is a 28 inches mill, driven from the No. 2 plate-mill engine, through steel bevel-gearing, and is reversed by means of a steam-clutch. The mill consists of one stand each of pinions and rolls, fitted with the usual live-roller frames, and screwing and edging gear. Cutting is done by means of a steam-hammer placed at right angles to the mill, and served by a steam jib-crane. This mill is capable of dealing with about 1,650 tons of ingots per week.

The No. 1 plate-mill has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, each 6½ feet long by 25 inches in diameter, driven by a high-pressure, direct-acting, non-condensing engine, with a fly-wheel weighing 70 tons. The steam-lift is capable of handling slabs weighing from 20 to 25 cwts. The capacity of the mill is equal to 400 tons of plates per week.

The No. 2 plate-mill is a clutch-reversing mill, and contains one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, each 7 feet long by 25 inches in diameter. The mill is driven by a high-pressure, direct-acting, non-condensing fly-wheel engine; and the reverse action is obtained by the five-wheel method and a clutch-motion. All the wheels, shafts and clutches are made of Siemens steel. The output of No. 2 mill is about 800 tons of plates per week.

Each of the preceding plate-mills has plate and scrap-shearing machines conveniently placed for its use. There are 6 Lancashire, 2 Babcock-Wilcox boilers, and 15 furnace-stack boilers, making a total of 23 boilers for driving these mills.

The No. 4 cogging-mill is a 45 inches mill, having one stand of pinions and one stand of cogging rolls, driven by an engine with a pair of coupled high-pressure, non-condensing, direct-acting cylinders, geared at 2½ to 1, the wheels, shafts and couplings all being made of Siemens mild steel. The mill is provided with live-roller gear on each side, and hydraulic edging gear on the delivery side. The top roll is balanced by hydraulic, and the screwing is effected by steam-power. In a line with the mill,

a large bloom-shearing machine is placed, driven by a high-pressure reversing engine, and provided with live rollers mounted in falling tables on the receiving and delivery sides of the shear. The ingots are heated in 6 vertical heating-furnaces, served by a steam-derrick locomotive crane. This plant is capable of cogging 2,600 tons of steel ingots per week.

The No. 3 plate-mill has one stand of pinions, one stand of roughing rolls, one stand of finishing rolls, and one stand of chequering rolls, the roughing and finishing rolls being each 6½ feet long by 25 inches in diameter, and the chequering rolls 5½ feet long by 25 inches in diameter, and all are driven by a high-pressure, direct-acting, non-condensing fly-wheel engine, geared inversely as 1½ to 1. The mill is furnished with a similar steam-lift to that at No. 1 plate-mill, and it is also equipped with the necessary plate and scrap cutting-shears. It produces about 380 tons of plates per week.

The No. 4 plate-mill is a 28 inches clutch-reverse mill, driven by a high-pressure, direct-acting, non-condensing fly-wheel engine, the reverse action being obtained by the five-wheel method and a clutch-motion, and all gearing and shafts are made of Siemens mild steel. The mill has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, these latter being 8 feet long by 28 inches in diameter. The delivery side of the mill is provided with a traversing steam-platform, constructed so as to work the plates to and fro through the rolls, and also to take them bodily from the roughing rolls to the finishing rolls; and the receiving side is fitted with live roller-frames. A 15 tons steam travelling-crane running overhead upon steel-built box-girders is used for roll-changing. There are 2 strong plate-shearing machines, each capable of cutting plates 1½ inches thick. The output of this mill is 1,250 tons of steel plates per week.

A battery of 14 hand-fired Lancashire boilers is installed outside of the roof area; and in addition there are, in the cogging-mills and plate-mills, 16 boilers, making a total of 30 boilers; 8 being vertical, 4 Lancashire and 4 Cornish boilers.

ANGLES, ETC.

The ingots for the angle-mills are supplied from the north melting-shop, containing 7 Siemens open-hearth furnaces, the charges for which are 28 tons. These furnaces are of similar con-

struction to those in the east and west melting-shops, but are laid out somewhat more conveniently, with ample space, and having unusually large and well ventilated valve-chambers. Gas is supplied from 15 Siemens producers, to the melting-furnaces, and these also are conveniently laid out for dealing with both coal and ashes. The ingot-producing capacity of these furnaces is 1,800 tons per week.

The 45 inches cogging-mill is driven by a high-pressure non-condensing engine, with 2 cylinders 45 inches in diameter by 5 feet stroke, fitted with piston-valves and Allan link-motion, and geared at 2 to 1. It comprises one stand of roll-housings, and one stand of pinions, seated upon cast-iron bed-plates. The mill, with live roller-gear on each side, is designed for dealing with slabs or billets. The capacity of this mill is about 2,500 tons per week.

The 32 inches angle-mill is driven by a reversing high-pressure non-condensing engine, with 2 cylinders 54 inches in diameter by 4½ feet stroke, fitted with piston-valves and Allan link-motion, and coupled direct to the mill by an inside crank-shaft and steel couplings. The mill, which is about 125 feet distant from the bloom-shear, has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, all coupled through steel boxes and spindles. The capacity of this mill is about 2,000 tons per week.

The 22 inches angle-mill is driven by a reversing high-pressure non-condensing engine, with 2 cylinders 40 inches in diameter by 4 feet stroke, coupled through steel boxes and spindles in the same manner as the 32 inches mill. It comprizes one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, with live roller-gear on the receiving and delivery sides, and an inclined shoot on the receiving side. The live roller-gear leads from the mill to the billet-shear and steam circular sawing-machine; and on a line with these is a relief live roller-frame for distributing the rolled bars, as in the 32 inches mill. The capacity of this mill is about 1,600 tons per week.

The 12 inches guide-mill is driven by a high-pressure non-condensing fly-wheel engine, with 2 cylinders 30 inches in diameter by 2½ feet stroke, fitted with piston-valve and governor-gear. It consists of one stand of pinions, one stand of roughing rolls, one stand of finishing rolls, and two stands of guide-rolls,

all coupled through steel boxes and spindles. A steam circular sawing-machine and billet-shear are likewise provided. This is a reheating mill, and two furnaces are conveniently placed, with stack-boilers attached. The capacity of this mill is about 350 tons per week.

The cogging-mill is served by a 25 tons overhead square shaft steam-crane; and two overhead cranes, each of 15 tons capacity, with attached boilers, traverse the three angle-mills and roll-turning shop, these being placed in one line and under one roof.

The roll-turning shop is placed at the end of the 32 inches mill, and contains three powerful lathes, each driven by its own engine.

The hydraulic plant comprizes two sets of Worthington high-pressure pumps, one accumulator and tank, with automatic governor gear attached, working to a pressure of 700 pounds per square inch.

There is a battery of 18 Lancashire boilers fired by automatic stoking-gear. They are arranged in pairs, and work through nine iron chimneys lined with brick. The mill-furnace boilers are of vertical type, with one internal flue fitted with cross tubes, and stand upon cast-iron columns. All the boilers are designed to carry a pressure of 100 pounds, and in daily working are pressed to 80 pounds per square inch. The steam-pipes, from 9 inches in diameter upwards, are made from Siemens mild wrought-steel in lengths up to 16 feet, welded from end to end, with solid flanges contracted and rivetted on.

The bar-bank is arranged at the southern end of the mills. Bar-skidding gear is provided, worked from the driving-engine through shafting, the friction-cones being set in motion by hydraulic-rams. The loading on the bank is done by two 3 tons steam locomotive travelling cranes, having 30 feet jibs.

There are the usual fitting, blacksmith, boilersmith, pattern-maker, joiner and other shops, where renewals and repairs to machinery and other plant are executed.

The foundry is situated at Crookhall, 1¾ miles from the main works, and has a capacity of 200 tons of castings per week. The plant consists of three cupolas, air-furnace, drying-stoves, loam-mill, and blowing-plant, with two 25 tons overhead steam-cranes, and one hand-power jib-crane. The ingot-moulds, and the whole of the castings necessary for mill and general ironwork repairs, are made here. There are pattern and blacksmith shops, and a brass-foundry.

The brick-works, about ½ mile from the iron and steel works, have a capacity of about 120,000 bricks per week. There are 10 brick-burning kilns, each equal to 18,000 bricks per load, fired by the waste-heat from four rows of coke-ovens immediately adjoining, the waste-gases from which are collected in one large flue, and, after passing through the kilns, are conveyed in small flues under the floor of the drying-shed. There are also a small mill and press for mixing and making ganister-bricks, which are burnt in two suitable hand-fired kilns.

The locomotives and locomotive-cranes are of various classes, and 55 are in general use. The locomotive repairing-shop is situated at Templetown, about 1 mile from the works, on the main line between the works and the collieries, and is furnished with all necessary tools and appliances.

DAWDON COLLIERY.

The first sod of the Theresa or south shaft was cut by the Marchioness of Londonderry, and the first sod of the Castlereagh or north shaft by Viscount Castlereagh, on August 26th, 1899.

Sinking operations commenced on April 17th, 1900.

Both shafts will be 20 feet in internal diameter when completed.

Theresa Pit.—The Theresa shaft is now 350 feet deep, and has 225 feet of cast-iron tubbing, and 96 feet of brick lining in it. The largest feeder yet met with in this shaft was 6,075 gallons per minute, at a depth of 196 feet from the surface.

The ground sunk through in this pit is as follows:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1.	Soil	1	0	1	0
2.	Strong clay	5	0	6	0
3.	Sand and gravel	3	0	9	0
4.	Marl with limestone-panels ...	6	1	15	1
5.	Marl	22	6	37	7
6.	Limestone	6	0	43	7
7.	Strong marl	66	0	109	7
8.	Strong marl, in blocks	64	8	174	3
9.	Hard limestone	60	6	234	9
10.	Grey marl	4	7	239	4
11.	Grey limestone	73	4	312	8
12.	Grey and yellow limestone, into ...	37	4	350	0

Several small bore-holes have been put down from the bottom of this pit, and it has been found that the sand lies 19 feet below the present pit-bottom. The sand is 84 feet thick. It is thought that the sand is somewhat solidified, and that it will be sunk through without much trouble.

In this shaft, there are pumps capable of delivering 7,000 gallons per minute, namely:—Two 24 inches and one 25 inches pumping sets, and two vertical sinking-pumps, with cylinders respectively 24 inches and 16 inches in diameter by 24 inches stroke, each capable of pumping 1,000 gallons per minute from a depth of 300 feet.

Sinking operations in this shaft have been suspended until the north pit reaches the same depth, so as to permit of both shafts being taken through the sand together.

Castlereagh Pit.—The Castlereagh shaft is at present 190 feet deep. It has the same amount of brick lining as the other shaft, but has only one lift of tubbing, 33 feet long, completed. At present, another lift of tubbing, 53 feet high, is being inserted. The present feeder is the greatest yet met with, amounting to 4,480 gallons per minute.

The section of this shaft is:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1.	Soil	1	0	1	0
2.	Clay	5	6	6	6
3.	Sand and gravel	4	6	11	0
4.	Strong marl, with limestone	50	10	61	10
5.	Limestone, with marly partings ...	32	7	94	5
6.	Marl, with gullets	90	0	184	5
7.	Hard limestone, into	5	7	190	0

To clear the water from this pit, a drift has been driven from the Theresa shaft in a northerly direction, and a bore-hole, lined with steel tubes $9\frac{1}{2}$ inches in internal diameter, has been put down into this drift, and the water, which runs downward, is pumped at the Theresa shaft. There is also a sinking-pump, similar to those in the other pit, hung in this shaft to pump the excess-water, which the bore-hole cannot drain off.

The water in both shafts is pumped into a drift, 90 feet below the surface, from which it runs to the sea-beach.

It is proposed, when the Castlereagh shaft reaches the same depth as the Theresa shaft, to put in four 30 inches sets of pumps —two standing sets and two sinking sets—for pumping the water, while going through the sand.

Engines, etc.—The sinking-engines have each two cylinders 24 inches in diameter, and a stroke of 4 feet. The drum is 6 feet wide, and 8 feet in diameter. The locked-coil rope is 3¾ inches in circumference. These engines will eventually be used as underground hauling-engines.

The pumping-engine for working the two 24 inches sets and one 25 inches set in the Theresa shaft has two cylinders, 36 inches in diameter and a stroke of 6 feet, and the flywheel is 24 feet in diameter.

The main crab-engine has two cylinders, 14 inches in diameter and a stroke of 3 feet; it is geared 16 to 1, and the rope is 6½ inches in circumference. The cylinders of the ground crab-engine are 8 inches in diameter and a stroke of 14 inches; it is geared 30 to 1, and works with a rope 5½ inches in circumference.

The foundations, 4½ feet thick, of the permanent winding-engine houses have been built, their outside measurements being 66½ feet by 48½ feet, and 23½ feet deep.

The permanent winding-engines will be of the Corliss-valve type, with cylinders 40 inches in diameter, and a stroke of 6 feet, and the drum will be 10 feet wide and 20 feet in diameter.

An engine is used for compressing air to drive the rock-drills used in the bottom of the pit.

Boilers, etc.—There are 8 Galloway boilers, each 30 feet long and 8 feet in diameter, fitted with two furnaces, 3¼ feet in diameter, working at a pressure of 100 pounds per square inch. There are also 3 locomotive-type boilers, but these are not being used at present.

There are four sets of Green fuel-economizers of 120 tubes each. The gases enter the economizer-flues at a temperature of 500° Fahr. and leave at 300° Fahr., and the water enters the economizers at 85° Fahr. and leaves them at about 240° Fahr.

The chimney for the Galloway boilers is 160 feet high, its base is 24 feet square, and the inside diameter at the top is 12 feet.

There are two water-softening tanks, each 15½ feet by 15½ feet

by 10 feet deep, holding 15,000 gallons each, and capable of treating 60,000 gallons per day. The water for boiler-feed purposes is softened in these tanks by the Archbutt-Deeley process, and the hardness, which is originally about 16 degrees, is reduced to 4 or 5 degrees. About 40 pounds of lime and 7 pounds of alkali are used for each tank treated, at a cost of about 0·46d. per 1,000 gallons.

SEAHAM HARBOUR WORKS.

The works under construction consist of:—(1) New Dock, 10 acres in extent, with 27½ feet of water at high water of ordinary spring tides; (2) entrance to dock, 200 feet long and 65 feet wide, with inner and sea-gates; (3) harbour-wall and sea-wall enclosing the quay-space; (4) North and South Piers, forming an outer harbour of 30 acres with an entrance, 300 feet wide; and (5) coal-tips, staging, etc.

The New Dock is built partly on the site of two old docks, namely:—The Old South and Old Dry Harbour, and partly on the foreshore. The Old South Dock is now being pumped dry. The excavation on the site of the Old Dry Harbour is completed, and that on the portion of the dock on the foreshore is in progress. The excavation is in limestone, which is blasted and then filled into wagons by steam-navvies. A good deal of water is met with.

The walls of the dock are built in cement-concrete, with a masonry-facing, for 13 feet from the top, finished with a granite-coping. The entrance is to be built in similar work. At present the western roundheads are built, and a cofferdam is under construction to enclose the remainder. This cofferdam, of concrete from 9 to 12 feet thick at the top, with a foundation from 12 to 20 feet wide, has been under construction for two years; large portions have been washed away during winter storms.

The North Pier is 1,335 feet long, 25 feet thick on the top for a length of 623 feet and 30 feet for 712 feet. The South Pier is 878 feet long, 20 feet thick on the top for a length of 578 feet and 25 feet for 300 feet. Both piers are built of concrete-blocks faced with freestone-ashlar. Those for the North Pier (which has to stand the heaviest gales) weigh 30 tons, and those for the South Pier 20 tons. The blocks are all made in the blockyard on the north side of the works, and those for the South Pier are taken round by a tunnel specially constructed for this purpose.

The blockyard is furnished with Taylor concrete-mixers. The gravel procured from the beach, and cement from the shed is taken up by the elevators to the mixers and passing through the mixers is led by narrow-gauge trucks to the various blocks. The blockyard is spanned by a goliath-crane of 100 feet span, capable of lifting 40 tons.

The blocks are set on a foundation of mass-concrete, which is laid on the rock under water by divers and levelled for the reception of the blocks. The piers are finished with a granite-coping on each side, and a subway runs the whole length of each and will enable the attendants to reach the lighthouse in stormy weather.

Owing to the exposed position, the preliminary work of enclosing the site, forming the ground for the blockyard, etc., has required considerable time. The severe storms in the autumn and winter of 1901-2 also caused considerable damage, the works being practically stopped for 6 months.

The plant in use on the works includes:—6 locomotives, 210 wagons, 3 steam-navvies, 8 cranes, 2 titan-cranes, 1 goliath-crane, 10 portable engines, 1 set of winding gear, 4 concrete-mixers, 11 steam-pumps, etc. About 400 men are usually employed.

HYLTON COLLIERY.

Hylton colliery is situated on the site of the Wear steel-works, on the northern side of the river Wear, about 2 miles above Sunderland.

Shafts.—There are three shafts: the east and west pits, each 20 feet in diameter, are used for coal-drawing, and the south pit, 15 feet in diameter, is the upcast and fan-shaft.

The east and south pits are sunk to the Hutton seam, with an average section of 4½ feet of clean coal, at a depth of 1,580 feet. The west pit has been sunk to the Maudlin seam, 5 feet 9 inches thick, at a depth of 1,440 feet. All three shafts are lined throughout with brick-walling.

Winding-engines.—The winding-engines at the east and west pits are in every way similar. They have 2 cylinders, 34 inches in diameter by 6 feet stroke, and are fitted with double-beat valves and automatic cut-off gear. The working steam-pressure is 120 pounds per square inch. The winding-drums are 20 feet in diameter on the cleading, which is of oak, 7 inches thick, fixed on

steel lagging-plates; they are fitted with strap-brakes worked by a foot-lever, in addition to powerful steam-brakes.

Winding-ropes, Pulleys and Cages.—The winding-ropes are of mild steel, 5¼ inches in circumference. The pulleys, carried on frames of steel lattice-work, are 20 feet in diameter; they are of German manufacture, the rim being built in segments and carried on the boss by tapered flat-steel spokes. The small cages, at present in use, will shortly be replaced by double-decked cages, carrying 4 tubs on each deck. An endless rope hung from the cage-bottoms counterbalances the winding-rope.

Heapstead and Banking-out Arrangements.—The heapstead is built on brickwork arches, the floor is of steel girders and concrete laid with a gradient, which allows the tubs on leaving the cage to gravitate to the tipplers, and, after being emptied, to run to the creepers at the back of the shafts, whence they are raised to a level from which they run automatically back to the banksmen.

The output of the colliery has, up to the present, been disposed of as unscreened gas-coal, and the jigging-screens which have been erected are not as yet in use as screens. All the coal is, however, passed over the picking-belts.

Ventilating Fan.—A Waddle fan, 25 feet in diameter at the blade-tips, is in course of erection, it will be driven by a tandem compound engine with cylinders, 18 and 30 inches in diameter by 24 inches stroke. This fan will replace a small furnace, which, up to the present, has produced ample ventilation; it is placed in the east pit at a depth of 940 feet, and, though only raising the temperature to a mean of 66° Fahr., it is producing a current of 80,000 cubic feet of air per minute.

Haulage.—It is intended to introduce an endless-rope system of main haulage; and secondary engines, placed inbye, having two cylinders 10 inches in diameter by 16 inches stroke, and driven by compressed air, will haul to the landings from the flats; some of these engines are already in use.

Air-compressors.—There are two Ingersoll-Sergeant two-stage air-compressors, one is already in use and the second is in course of erection. The steam-cylinders are 18 and 30 inches in diameter, the water-jacketted air-cylinders are 25¼ and 16¼ inches in diameter by 24 inches stroke. The air leaves the low-pressure cylinder at 38 pounds, and passes through the intercooler to the

high-pressure cylinder, where the pressure is increased to 100 pounds per square inch.

Lighting.—The whole of the surface and the shaft-bottoms are electrically lighted, the current being supplied from a Tyne dynamo driven by a 50 horsepower Robey engine. The output of the dynamo is 400 ampères at 110 volts at 600 revolutions per minute, being equivalent to 750 lamps of 16 candlepower.

Boilers.—One battery of 6 Lancashire boilers, 30 feet long by 8½ feet in diameter, is already seated, though only 4 are in use, supplying steam at a pressure of 120 pounds per square inch. A similar battery will be put down shortly to replace the old boilers of the steel-works, as they cannot safely be pressed beyond 75 pounds.

NEWCASTLE-UPON-TYNE CORPORATION TRAMWAYS: MANORS POWER-HOUSE.

The power-station for the tramway system is located almost in the centre of the area of supply, and consists of large steel-framed buildings, with brick-walls.

A connection, from the railway, runs at a high level over a timber and steel elevated road, and the coal is discharged direct from the hoppered railway-wagons into the bunkers above the boilers, from which it is fed by automatic weighing-machines into automatic stokers. For steam-raising purposes, there are 8 Lancashire boilers, each 30 feet long by 8½ feet in diameter, working at a pressure of 160 pounds per square inch, with economizer and natural draught. The brick-chimney is 177 feet high.

In the engine-house, there are 3 marine-type engines, fitted with Corliss valves, two of 1,000 horsepower each, and one of 2,000 horsepower. The engines are provided with surface-condensers, and Edward air-pumps.

Three dynamos are coupled direct to the three engines, and supply current at a pressure of 500 volts through a large switchboard to the traction-mains. In addition, current is supplied from the same switchboard by separate feeders for the arc-lighting of the town.

Circulating water for the surface-condensers is provided from the River Tyne, which is about ¼ mile distant from the station, and 90 feet below the level of the engines. Two large mains 24

inches in diameter, are run down to a pumping-station alongside the quay-wall, where two centrifugal pumps force the water to the power-station up one pipe, and the water returning by the other pipe, drives turbines, which help to drive the pumps, the surplus power, due to friction, loss of head, etc., being supplied by motors coupled direct to each pump.

There are at present 16½ miles of double tramway-track in use, and about 165 cars of various types, bogie and 4-wheeled, for which there is one car-shed in the centre of the town, another at the extreme northern end at Gosforth, and the third at the eastern end, at Byker. The latter forms also a machine-shop for repairs and building of cars.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED: ELSWICK WORKS.

The steel-works were opened in 1883, with the idea of supplying gun-steel to the Ordnance works, but of late years large quantities of outside orders have been undertaken.

The steel-works, at the eastern end of the Elswick works, extend over a length of 1,100 feet, and cover an area of about 50,000 square yards. The melting-plant comprises 8 furnaces, which are capable of a weekly output of upwards of 1,200 tons of steel, and ingots can be cast up to a weight of 80 tons.

The forging plant is worked hydraulically, and can turn out 120 tons of forgings per week. There are 4 large forging presses and several smaller ones. The largest of the presses exerts a pressure of 5,000 tons. The pressure required by the forging plant is supplied by 5 Corliss pumping-engines, each indicating 1,000 horsepower. Propeller-shafting has been forged under the forging presses in lengths of 80 feet, which shafting has afterwards been trepanned from end to end.

In the foundry, steel castings for gun and carriage work, marine and electrical general machinery and anchors, and the largest stem and stern-posts and rudder-frames are manufactured. The weekly output of castings amounts to about 60 tons.

There is an extensive plant of heavy machinery for dealing with forgings and castings.

The department employs about 2,000 hands.

NORTHERN WOOD-HASKINIZING COMPANY, LIMITED.

The haskin system of treating wood consists in placing the raw timber in a large steel cylinder or treating chamber, and superheated air is applied under great pressure. The high temperature, ranging from 300° to 400° Fahr., is sufficient to destroy the tendency to germinate, and to kill all fungi, germs and insect life in the wood; and to produce a much higher percentage of antiseptic and preservative matter than is found in untreated timber. With the high pressure employed, evaporation or bubbling of the essential oils or sap in the wood is entirely prevented, and the chemical changes which take place, as a consequence of the application of heat, penetrate to, and remain in, every particle of the fibre. Before removing the wood from the cylinder, it is allowed to cool down under the same pressure, with the result that the new compound arising from the heating of the natural fluids in the wood is consolidated with its fibre.

Haskinizing considerably lengthens the life of timber in actual use, and by its consolidation of the fibres of soft, succulent varieties of wood, which are thus made stronger and more durable, very important economies may be effected. The process is applicable to every species and variety of timber, fitting it for immediate use for every purpose, from the coarsest qualities suitable for outside work to the finest kinds required for structural and cabinet work, carving, interior decorations, etc. No extraneous matter is used in the process, and no offensive odours are emitted from the wood after treatment.

Tests of the transverse and crushing strength have been made of three logs of pitchpine. Each log was cut into three pieces, one of which was left in its natural state, a second was haskinized, and the third was creosoted, making nine pieces available for the experiments. The tests, as certified by Messrs. Kirkaldy & Son, indicated that the modulus of rupture by transverse stress was 14 per cent. higher for the haskinized wood than for the untreated, and 29 per cent. higher than for the creosoted wood. The crushing strength of the haskinized wood was 4 per cent. above that of the untreated and 7 per cent. above that of the creosoted wood. Chemical analysis showed that there was 27 per cent. of resinous preservative constitutents in haskinized wood, as compared with 10 per cent. in similar untreated wood.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY, LIMITED: NEPTUNE-BANK WORKS.

General Notes.—In June, 1899, the Walker and Wallsend Union Gas Company obtained Parliamentary powers to supply the urban districts of Wallsend and Willington with electric power, and proceeded, in January, 1900, with the erection of a power-station on a site midway between Carville and Walker, close to the Riverside branch of the North-eastern railway. In October, 1900, the Newcastle-upon-Tyne Electric Supply Company, Limited, purchased the entire plant put down by the Gas Company, with the exception of the cables and sub-station machinery installed for the purpose of supplying the works in the area in which the Gas Company had obtained Parliamentary powers. The Supply Company further entered into an agreement with the Gas Company, in which the latter undertook to buy electricity in bulk from the former. The Supply Company also obtained, further powers authorizing them to lay high-tension cables from their power-house at Wallsend to various sub-stations in Newcastle-upon-Tyne. At the same time, they decided to change their entire system of supply, which, up to this date, had been by means of single-phase alternating current generated at Pandon-dene power-station at a pressure of 2,000 volts, with house to house transformers. The new scheme included the generation of three-phase current at 5,500 volts, having a periodicity of 40 cycles per second, and the transformation of the same to continuous current by means of motor generators in sub-stations each designed to have a total capacity of 2,000 kilowatts. In the beginning of 1901, the work of changing the lighting network from alternating to direct current was started, the direct current being on the three-wire system (2 by 240 volts). It may be of interest to note that, since the Neptune-bank power-station started work, motors having the aggregate capacity of over 4,500 horsepower have been connected. These motors are used in all classes of trades, and vary in capacity from ½ to 50 horsepower.

Power-station.—The boiler-house, which is of corrugated iron, adjoins the engine-room on the south side. The dimensions of each building are 160 feet by 52 feet. On the north-east of the power-house lies the cooling-pond, where the circulating-water

is cooled by means of spray nozzles, capable of cooling 4,000,000 pounds of water per hour. This system of dealing with the circulating-water was adopted because of the great cost of pumping sufficient water direct from the river, which is some 60 feet below the level of the power-station.

On the other side of the power-house, is the testing-pond, which is capable of absorbing 1,500 kilowatts.

The overhead line (low-tension three-phase, and direct current) leaves the power-house on this side; it is used for a supply of current to the Neptune engine-works, and the Walker shipyard.

Boiler-house.—There are four batteries of Babcock-Wilcox boilers, each consisting of 2 boilers of about 1,000 horsepower, fitted with superheaters, mechanical stokers, etc. The working pressure is 200 pounds per square inch and the superheat ranges from 100° to 120° Fahr. Each boiler has a heating-surface of 4,020 square feet, and will evaporate 14,000 pounds of water per hour.

Among the fittings is an apparatus for determining the quality of the flue-gases. An economizer, with 280 tubes and the usual motor-driven scraper-gear, serves to heat the feed-water before entering the boilers.

The steam-pipes are made of solid-drawn steel tubes; one main header, 7 inches in diameter, supplies the main engines; and a separate header is used for the auxiliary engines.

The ashes are discharged into trucks in the ash-tunnel and are raised by an elevator at the south-eastern end of the house. An electric locomotive of 20 horsepower is used for conveying coal to the boiler-house from the railway.

Engines and Generators.—At present, there are nine sets varying from 50 to 1,500 kilowatts.

The engines of Nos. 1 and 2 sets are of 300 horsepower and drive two direct-current generators, which are used for supplying the direct-current network in Walker and Wallsend. The engines are compound, of the two-crank type, and run at 380 revolutions per minute. The generators are compound-wound and provided with equalizing switches. The armatures are slotted and are drum-wound. The magnets are of mild steel.

The No. 3 set is of 50 kilowatts capacity and generates current at 240 volts for exciting purposes only.

The No. 4 set is used both as a balancer and as a motor generator. The high-tension side consists of a synchronous motor which drives two compound-wound generators. The total capacity of the two direct-current generators is 150 kilowatts.

The engine of No. 6 set, of 1,400 horsepower, is of the marine type, with Corliss valves and Whitehead governor for normal working at 100 revolutions per minute. When the speed exceeds 115 revolutions per minute, an Aspinall emergency-governor comes into play. The cylinders of this engine are 17½, 28½ and 48 inches in diameter respectively, and 3 feet stroke. The specified variation from normal speed when the load is thrown off is 5 per cent., the normal variation was specified not to exceed 2 per cent., and at the official trials the variation in speed was within the limits named. The generator, of 750 kilowatts, is wound so as to give 2,500 volts (the original working pressure), or 5,500 volts, at a periodicity of 40 cycles per second. The armature is built of soft grade sheet-iron, and is ventilated by means of spaces, which allow a free circulation of air in contact with the winding. The form-wound armature-coils are laid in slots, of which there is one pole per phase. The pole-pieces are built up of high permeability punchings. The field-winding consists of copper strips, the magnets being excited at 240 volts. The efficiency is 95 per cent. at full load, and 91½ per cent. at half load. All the three-phase machines are star-wound, with the middle point earthed.

For Nos. 7, 8 and 9 sets, the engines (1,400 horsepower each) have four cylinders each, 19, 31, 34 and 34 inches in diameter and 3 feet stroke. The four cranks are not set exactly at right angles, the engines being specially balanced on the Yarrow-Schlich-Tweedy system. These engines are furnished with Stumpf fly-wheel type governors. The generators coupled to the engines are precisely similar to that driven by No. 6 engine.

The No. 10 set consists of a Parsons turbine, coupled direct to a 1,500 kilowatts generator. The turbine is one of the largest yet manufactured, and the steam expands uniformly from 200 pounds to vacuum-pressure. It is provided with the Parsons mechanical governor for normal running, and also with a centrifugal-type governor designed to shut off steam when the turbine attains a speed 20 per cent. greater than its normal rate. The condenser and the air-pump are situated immediately below

the turbine. The Parsons air-pump is capable of producing a vacuum of 29 inches. The exhaust-pipe is 36 inches in diameter, a size necessitated by the unusually low pressure of the exhaust-steam. The bearings are of white metal, with forced lubrication. In a recent test of this set, the amount of steam used per kilowatt per hour was found to be 17·8 pounds: a figure which compares most favourably with engines of the reciprocating type. The generator, unlike all the other high-tension machines in the station, has a revolving armature with fixed fields. The collector-rings are insulated from the wooden sleeve which carries them, by means of mica. It has been found that hunting of the synchronous motors at the sub-stations is less pronounced when these are worked from the turbo-alternator than from the reciprocating sets.

Switchboards.—On the high-tension switchboards, all the main feeder switches have oil-breaks, and the remainder break in air. The board is furnished with the usual synchronizing gear in duplicate, also wattmeters and ammeters. Below the high-tension switches are the field-switches, provided with carbon-breaks; also the hand-wheels for regulating the field-resistances. A subsidiary switchboard is erected in a building on the northern side of the power-house. The main high-tension feeders, which are coupled up to this board, are furnished with spark-gaps, connected across the cores. Their object is to allow a discharge to take place, in the event of the normal voltage being exceeded from any accidental cause.

The low-tension switchboard is provided with three sets of omnibus-bars, one set is in connection with the low-tension network, one set is used for exciting purposes, and the remaining set is used to supply the station lighting and power. In addition to this main board, there are two sets of low-tension panels situated beneath the gallery. These are respectively for the equalizing and starting switches, and for the low-tension meters. Behind the board, are the lighting arresters in connection with the overhead line.

Sub-stations.—There are four principal sub-stations in the Newcastle-upon-Tyne area, in addition to one at Wallsend owned by the Walker and Wallsend Union Gas Company. Besides

these, each of the large manufacturers has a sub-station containing static transformers and high-tension switchgear.

In the Manors sub-station, which is a typical example of these buildings, there are installed two 500 kilowatts motor-generators, one 75 kilowatts induction-motor generator, used for starting the large synchronous sets and one 25 kilowatts balancer. The switches, which are situate in the basement of the building, break in oil, and are so arranged that they can be manipulated from above, thus obviating the necessity of having high-tension connections on the gallery. The high-tension switchboard is furnished with synchronizing lamps and voltmeters, connected to transformers in the usual manner. In addition to the voltmeters and ammeters, there is an indicating kilowatt-meter and a direct-reading power-factor indicator. There are also two induction-meters for measuring the units supplied to the station. All these instruments are connected to transformers placed in the basement. The low-tension switchboard is arranged with the positive and negative panels placed on either side of the central neutral panels. On the back of each set of panels, three omnibus-bars are mounted, any one of which can, by means of the plugs and switches in front of the board, be connected to any feeder or generator. Below the low-tension switchboard on the ground level are the field-switches and the main-generator fuse. The sub-stations are all interconnected by special cables, so that any portion of the network can be supplied to any sub-station.

The station at Pandon Dene, which previous to the completion of the transmission line from Wallsend was used as a generating-station, is now being converted into a sub-station with motor-generators similar to those in use at the Manors.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

EXCURSION MEETING,

HELD AT DÜSSELDORF AND IN THE RHENISH WESTPHALIAN COAL-FIELD, SEPTEMBER 8TH TO 13TH, 1902.

DORTMUND MINING-DISTRICT.

The progress of the coal-industry in Germany is manifested by the following figures:—

Years.	1875.	1885.	1895.	1900.
	Tons.	Tons.	Tons.	Tons.
Dortmund ...	16,983,000	28,970,000	41,146,000	59,619,000
Breslau	10,444,000	15,786,000	21,944,000	29,597,000
Bonn	5,550,000	7,634,000	8,974,000	11,980,000
Saxony	2,991,000	4,151,000	4,430,000	4,804,000
Other districts ...	1,468,000	1,779,000	2,675,000	3,209,000
Totals... ...	37,436,000	58,320,000	79,169,000	109,209,000
Dortmund: Persons employed	83,000	105,000	153,000	225,000

In the Dortmund mining-district, the rate of increase in the number of persons employed was 47 per cent. during the 5 years. 1895 to 1900, while the increase in the output was 45 per cent., shewing that the increased output was obtained with a proportionate increase in the number of persons employed. In 1900, hewers earned on the average £77 per annum or £1 9s. 7d. per week, while other classes of labour earned about £55 a year or £1 1s. 2d. per week.

The realized prices per ton for the products of the collieries have fluctuated considerably, as follows:—

Year.	Gas-coal.	House-coal.	Coke.	Briquettes.
	s. d.	s. d.	s. d.	s. d.
1887	7 2	5 10	8 9	7 4
1890	14 8	12 4	22 0	14 8
1893	9 10	7 9	14 0	9 10
1896	10 2	8 0	14 3	10 2
1897	11 3	8 7	16 0	11 0
1899	11 9	9 3	16 10	12 1
1900	12 10	10 2	23 4	13 7

The realized prices are at present much lower than those of 1900.

The compensation paid for accidents averaged as follows:—

Year.	Non-fatal Accidents.	Total Accidents.	Both Classes of Accidents.
	£	£	£
1886	14	13	14
1890	31	42	34
1895	42	77	50
1900	51	103	62

DÜSSELDORF EXHIBITION.

The exhibition contained specimens of all descriptions of manufacture and production from the provinces of Rhineland and Westphalia, but was exclusively confined to these provinces, and was in no sense international. The variety and excellence of the exhibits in all departments was extraordinary.

The large model of the Rhenish-Westphalian coal-field (which was mounted upon an elevated platform) consisted of 38 glass-plates, each of which constituted a north-and-south section across the coal-field. The five principal seams (the Hauptflötz, Mausegatt, Sonnenschein, Catharina and Bismark) are shewn, together with the faults and dislocations which have been proved. The shafts are shewn to the depth to which they have been sunk, and the foldings of the seams named are clearly exhibited, thus indicating the coal which remains still to be worked throughout the coal-field. One is greatly struck by the immense quantity of coal lying beneath the level of the deepest shafts, and which probably may never be reached—owing to the

great depth and the high temperature no doubt prevalent at that depth. The overlying marls of the Cretaceous formation, which cover the Coal-measures to the north, are shewn. This model was prepared at the Mining School at Bochum, and is one of the most perfect and interesting models of the kind that has ever been constructed. A map made in 1806 showed that the coal-field, at that time in operation, extended very little to the north of the river Ruhr, which now forms its southern boundary.

The following is a selection of a few of the interesting models and exhibits contained in the Mining Building:—

(1) Complete working model of the Pattberg method of sinking shafts through wet and soft measures.

(2) The Tomson arrangement for drawing large quantities of water by means of large cylindrical tanks, A, was shewn in an excellent model (Fig. 1, Plate XXII.). Two collecting-tanks, B, are employed, suspended at a convenient distance above the sinkers by means of wire-ropes, C and D, which pass over pulleys on the headgear to a capstan-engine. These ropes also act as guide-ropes, a rider, E, being used for guiding the water-barrels in the shaft. The collecting-tanks, B, are connected together by pipes, and the water is pumped into them by means of a pump, F, attached to the tank by steel channel-bars, G, H. The collecting-tanks are prevented from turning round by means of baulks temporarily fastened in the shaft. The compressed-air pipes (for supplying the pump) are carried in the shaft by means of wire-ropes, clamped to the pipes at fixed intervals; and the ventilating air-boxes are carried in a similar manner, the ropes being weighted to keep them taut (Fig. 2, Plate XXII.). The collecting-tanks are 5 feet 7 inches in diameter and 27 feet in length, and the water-barrels are 4 feet 11 inches in diameter and 23 feet long. The water-barrels are drawn by a winding-engine in precisely the same way as ordinary coal-work, one barrel ascending while the other is descending. At the bottom of each is a valve. The descending barrel enters the tank and is filled, while the ascending tank is discharged by an automatic arrangement at the same moment. All water produced in the shaft above the tanks is led directly into the tanks, and is not allowed to run into the bottom of the pit. The filling, winding

and emptying of the barrels occupies about 2 minutes for a depth of 1,800 feet, though this, of course, will vary with the depth. The Tomson arrangement enables 1,100 gallons of water to be drawn per minute. This system of winding water was adopted by Prof. W. Galloway in South Wales in 1888, and was extended by Mr. Tomson in 1892.

Prof. W. Galloway states the principal arguments in favour of winding water in sinking operations rather than pumping it, as follows:—"The appliances are not costly; they are of the simplest description; they are not liable to get out of order; they are not affected to any appreciable extent by water containing sand or sediment of any kind; they can be raised or lowered in the shaft by operating at the surface and, therefore, cannot be drowned; they require no buntons to support or guide them; they can be cleared out of the shaft in a few hours, leaving it wholly free, and can, if necessary, be replaced by other larger appliances of the same kind, at a minimum of time and cost; and lastly, provided that the winding-engine is sufficiently powerful, they can be applied at any depth to raise the water direct to the surface without requiring to be duplicated or triplicated as in the case of pumps."*

The section of the shaft (Fig. 1, Plate XXII.) shews the position of one of the collecting-tanks, B, with the pump, F, attached to it; one of the water-barrels, A, and the sinking kibble, K. The surface-plan (Fig. 2, Plate XXII.) gives the position of the sinking-engine for winding the kibbles, the winding-engine for the water-barrels, the capstan-engine carrying the water-tanks, and two crab-engines carrying the compressed-air pipes for the pump and the ventilating air-pipes.

(3) The Castrop Explosives Company exhibited a model of their experimental gallery. The experimental gallery consists of nineteen rings of 4 inches wall-thickness. The mortar or cannon is bricked in directly above the sole, and its axis meets the apex-line of the tunnel at a distance of 33 feet from the end, which is closed by strong iron-plates. The mouth is usually open, but it can be closed immediately after a shot is fired. A mixing-apparatus and a ventilating-pipe are placed above, and

* *Course of Lectures on Mining*, Cardiff, 1900, Subject 2, Shaft Sinking, page 18.

the necessary machinery is erected in an adjoining building. The ventilating-pipe is generally closed by a heavy iron-lid, and samples can be taken at any time. There are no heating or cooling pipes in the gallery. The air and gases introduced are exhausted through a pipe, jacketed either with steam or cold water. The exhauster is driven by an electric motor, with which it is directly coupled. The dust, falling in from the stationary mixing-apparatus placed above, is stirred up by another fan, which is rope-driven by an electric motor. The gas-chamber is about 16 feet long. The whole gallery is lagged outside with 1¼ inches of felt and asbestos, and it is further encased in painted sheet-zinc so as to exclude moisture.

(4) A model of the systems of working coal at the Consolidation colliery, Schalke, shewed the different systems of timbering and working coal in steep seams.

(5) Model of the shaft-arrangements at No. 2 pit, Neumühl colliery. This shaft is an upcast winding-shaft, and both it and a portion of the pit-bank are enclosed from the outside air. The diameter of the shaft is sufficient for an air-current of 400,000 feet per minute, and for an output of 3,600 tons daily. The coal is dealt with automatically, and by means of a revolving-drum is delivered on to a conveying-band situated in the outer air. This drum is divided into six compartments, and revolves within a cover so arranged that there are always two to four of the compartments closed against the outer atmosphere. The small coal passes from the jigging-screen into a box or holder filled with water, and is conducted away by a bucket-conveyor. The water acts as a seal against the outside air. The stones can also be put into large storing hoppers provided with airtight sliding-shutters, above and below. When the hopper is being filled, the top-shutter is open and the bottom one closed; the reverse is the case when the hopper is being emptied, and the outside air is thus excluded.

(6) The small Dingler mine-fan is intended more especially for ventilating splits of air, and can only be used for blowing, but not for exhausting air. When mounted on a wooden framework it can be conveyed through a road 3¼ feet high and 4¼ feet

wide. It can be transported in four pieces, each of which will pass through an opening 2¼ feet high by 3½ feet wide. This fan uses little power, the central lubricator enables it to run for several days uninterruptedly, and the cover can be turned round, thus enabling the air to be emitted in any desired direction.

(7) Models of conveying-plants, rope-clips, etc., exhibited by Mr. George Heckel. An efficient and very simple arrangement was shewn for stopping runaway tubs upon an endless-rope road. The tub strikes a lever, A, fixed between the rails, which in its turn pulls over another lever, B, about 9 feet in front, to which it is connected by means of a rod or wire-rope. At normal speed, the tub, passing over the first lever, A, does not reach the second lever, B, until the balance-weight, C, has caused it to drop. Should a tub become detached and attain a speed greater than that of the haulage-rope, it reaches the second lever, B, which acts as a stop-block, before the balance-weight, C, causes it to fall out of position (Fig. 3, Plate XXII.).

(8) Mr. Friedrich Pelzer exhibited several fans. He claims the following advantages for them:—Freedom of entry and exit of the air, higher manometric and mechanical efficiency, and equalization of the pressure on both sides of the fan. The fans shewn included a 9 feet fan, a high-pressure fan for cupolas and smithy fires, four hand-fans, and two turbine-ventilators, 16 and 24 inches in diameter.

(9) A lamp-room with complete arrangements, exhibited by Messrs. Freimann & Wolf. This exhibit comprised a benzine-room with filling arrangements, electro-magnets for opening and closing the lamps, electrically-driven cleaning-machine with dust-exhauster, lamp-examining arrangements, and apparatus for testing safety-lamps, lamp-shelves with workmen's, officials' and testing lamps, as well as a charging-apparatus for electric pit-lamps.

An acetylene safety-lamp, suitable for pit-porches or examination of shafts, is designed to give a light of 7 candle-power for 10 hours. The water is contained in an annular jacket, which slides on the outside of the carbide-chamber. In this way, the production of the acetylene can be regulated and the light adjusted.

(10) A model of the complete surface-plant of the Shamrock III. and IV. colliery of the Hibernia Mining Company.

(11) The new type of Baum coal-washer is stated to have distinct advantages over its predecessors: it is simplified, requires less water and power to drive it, takes up less room, and is less costly; the essential difference between the old and the new type being that, in the latter, the material is washed first and then classified.

(12) The Brunck coking-plant with bye-product recovery, at the Minister-Stein colliery, has a capacity of 250,000 to 260,000 tons of coal with 10 to 12 per cent. of moisture, which yields 2,800 to 2,900 tons of ammonium sulphate, and 7,500 to 7,800 tons of tar. The waste-gases may be used to fire boilers with a heating-surface of 17,200 square feet, producing 550 tons of steam daily for colliery-purposes, or it may be used to produce 2,000 to 2,500 horsepower in gas-engines.

The special construction of the Brunck oven consists in a divided vertical heating-flue passing through a strong middle wall, by which each oven-chamber is provided with an automatic heating-system of 6 burners.

(13) Coal-drying apparatus. This apparatus does away, to a considerable extent, with the necessity for hoppers and the apparatus connected therewith, and enables the smudge to be satisfactorily mixed with the coking-coal when dried. The principle depends on a vertical spiral case, revolving at a high velocity inside a tower, with gauze-sides, through which the water is ejected.

(14) The colliery-village belonging to the Stein and Hardenberg collieries consists of 125 houses of eight different types, and provides accommodation for 470 families. The houses are sub-divided for 2, 4 and 6 families, and every family is allotted 250 square yards of garden-ground. Each dwelling has a separate entrance. Water is laid on to each house, and the closets are on the Gruben system. Each house is surrounded by a quickset hedge, separating each garden. The rents for the single dwellings per year are:—For 3 rooms £5 10s., for 4 rooms

£7 4s. and for 5 rooms £9. The cost of the village, including ground and interest, amounted to £145,000 (Fig. 9). In the central square is an institute, consisting of a central block and two wings, comprising an infant-school, reading-room and library, baths for men and women, two continuation-schools and dwellings for the teachers, manager and staff.

FIG. 9.—MINERS' COTTAGES AT THE DÜSSELDORF EXHIBITION.

(15) The miners' baths and buildings, at Scharnhorst colliery, are entered by the workmen (on their way to the pit) through a principal entrance. On either side of the passage are offices for the manager, deputies, engine-wright, cashier, etc., and bath-rooms for the officials. In the middle of the building are situated the check-office and the lamp-room. The miners' baths are divided into two parts, each of which is sufficient for 1,000 workmen. One is already in use, the second is equal in size and will be completed when required. The undressing room is divided into compartments, from which the workmen can proceed to the shower-baths. The men who are going to work pass by the lamp-room and up an overhead staircase to the pit-bank. The men returning from work go down the other side of the staircase to the lamp-room and thence to the baths.

(16) The Kuhn coal-compressing machine, for charging coal into coke-ovens, is intended to produce a strong coke, and enable otherwise unsuitable kinds of coal to be turned to account.

(17) The Express underground pumping-engine will lift 418 gallons of water to a height of 2,500 feet at 146 revolutions per minute. It is driven by a three-phase electric motor. This pump possesses the advantages of high speed, simplicity, and takes up little space, and is, therefore, very suitable for underground work.

(18) Messrs. Haniel & Lueg exhibited a large underground pumping-plant intended to deal with water from a number of mines at a central point. It is capable of pumping 5,500 gallons of water per minute to a height of 1,638 feet. The triple-expansion-engine has a high-pressure cylinder 37·4 inches in diameter, the middle cylinder is 59 inches in diameter, and the two low-pressure cylinders are each 65 inches in diameter; the stroke is 67 inches; and working at a speed of 60 revolutions per minute, it has a piston-speed of 11 feet per second, a speed which has not been reached in any other pump. The machine stands in an engine-room not exceeding 26 feet in breadth, and the consumption of steam will not exceed 14·8 to 15 pounds per horsepower-hour measured in the water raised.

(19) The Tomson compound overhead winding-engine, of 800 horsepower with two spiral drums, exhibited by the Harpen Colliery Company, is designed for winding from a depth of 4,900 feet at the Preussen II. colliery. This engine is a duplicate of that which has been working for some years at the Preussen I. colliery. The cylinders work upon an intermediate shaft, which is coupled by means of connecting-rods to cranks on two spiral drums, placed one behind the other. This arrangement avoids the excessive weight of two massive drums being placed on a single shaft, and obtains a better lead for the ropes. The diameter of the cylinders is 32 inches and 45 inches respectively, and the stroke is 8½ feet. The conical drums range from 18 feet at the smallest diameter to 33 feet at the greatest, and the breadth is 11 feet 4 inches. A remark was made that "this engine, perhaps, represents the last word of

the nineteenth century in winding-engines, but not the first of the twentieth century," and the latter phrase may perhaps be applicable to the electric winding-engine described in the following paragraph.

(20) The electric winding-engine, for the Zollern colliery of the Gelsenkirchen Colliery Company, is intended to raise 1,000 tons of coal in 6 hours, by 2·13 tons of coal at each wind, from a depth of 1,638 feet, with a maximum velocity of 65·6 feet per second. The drum is on the Kœpe system, that is to say, the rope passes round the drum for about two-thirds of its circumference in a groove, and the two ends of the ropes are attached to the two cages. This system is particularly suitable for electrical construction, on account of its narrowness. The diameter of the drum was fixed at 19·7 feet, with the object of securing sufficient adhesion for the rope, and at the same time reducing the size of the electric motors by obtaining a higher velocity. The arrangement is very simple:—On each side of the drum, two motors are placed, each capable of developing 1,400 horsepower on the main shaft, the ends of which are supported by two broad pedestals. The separation of the electrical driving into two parts was selected so that by running either in parallel or in series it is possible to attain the maximum velocity of 66 feet per second or 33 feet per second; and also so that in case of accident to one of the motors, the other will work the engine with a somewhat reduced load. By means of an arrangement of storage-batteries and through the excitation of the field-magnets, the motors can be run at other speeds without any waste of energy, for instance 6, 12, 16, 20, 26, 33, 40, 52 and 66 feet per second. The machine is fitted with a Baumann indicator, which regulates the maximum-velocity of the load as it approaches the surface, and should this velocity be exceeded the brake is automatically brought into action. The continuous current at a pressure of 500 volts is supplied from steam-driven generators, working in connection with an arrangement of storage-batteries, which permit of an adequate reserve of energy—an important requirement in work of such an intermittent nature as winding—and enable the maximum speed to be obtained at starting with a minimum loss of energy. The gradual increase of the voltage is achieved by grouping the

storage-batteries in four groups, which are separated by little starting resistances. These are connected with the starting mechanism placed in the basement beneath the driver's stand. The shaft of the starting mechanism is carried through the engine-house floor and connected by a rack-and-pinion arrangement to a compressed-air auxiliary-engine, with a working and a regulating cylinder, bolted to a foundation-plate, the pistons being mounted on a common rod. The working piston is operated by compressed air, and the other piston serves to moderate its action. The gearing is on the differential principle, and the motion of the piston-rod brings the distribution-valve into its central position. The compressed-air engine is worked by the driver, and acts on the switch-lever; the travel of the piston is equal to that of the lever in the guide-slot. When the engine is at rest, the lever is inclined towards the driver; when the lever is placed in the right-hand catch the engine will raise the right-hand cage or *vice versa.* Another lever, placed beside the switch-lever controls the compressed-air brake, and this is made to act only when the switch-lever is placed in the no-current position. The compressed-air cylinder acts on four brake-blocks, and is operated either by the hand-lever, or automatically in connection with the Baumann safety-indicator. In case the air-brake should fail to act, the driver can stop the engines by a counter-weight brake.

(21) The Tomson boiler consists of two Cornish-type boilers, which together have a heating-surface of 270 square feet, and a water-tube boiler with a heating-surface of 1,564 square feet. The Cornish boilers are 5 feet 10 inches in diameter and 13 feet 1 inch in total length, with a capacity of 424 cubic feet; while the tube-boiler has a capacity of about 250 cubic feet. The latter contains 96 tubes, each 17 feet long and 3¾ inches in external diameter, two welded water-chambers, and, connected with these chambers, a surmounting steam-chamber, 21 feet 4 inches long and 3 feet 7 inches in diameter. Under normal working conditions 1 square foot of heating-surface will evaporate 3·6 pounds of water per hour. At the Preussen I. colliery, 9 pounds of water have been evaporated in a Tomson boiler by 1 pound of coal. The combination of internal firing with the water-tube boiler enables the heating gases to be

utilized to their fullest extent, and as the live flames do not come directly into contact with the tubes, the latter very rarely exceed a temperature of 800° Fahr., and there is, therefore, very little wear upon them.

(22) Messrs. Göhmann & Einhorn showed various lavatory and bath-appliances specially intended for use at collieries, including elaborate baths and showers for the higher colliery-officials; similar baths of a simpler kind intended for the use of the overmen, deputies, etc.; for miners' baths, a sufficient number of shower-baths and a large undressing-room. Alongside the wall of the undressing-room, under the windows, is placed a long sink or trough where the men can wash their hands and faces. The miners' clothes are also left in this room, where they are drawn to the roof by means of cords and pulleys. Two heat-radiators are placed in the roof in order to dry the clothes.

In another room is shewn apparatus for cleansing and disinfecting clothes. There is also a model workmen's closet, made in white glazed earthenware.

SHAMROCK COLLIERIES, HERNE.

The Hibernia Mining Company own eight collieries and a total area of coal-field of about 25 square miles. In 1901, they employed 13,667 men and boys, and had an output of 3,573,050 tons of coal.

The Shamrock III. and IV. colliery is justly regarded as one of the model collieries in the Westphalian district. The two shafts are each 16 feet 5 inches in diameter. The upcast-shaft is not used for coal-winding; but the downcast-shaft is divided, so as to allow of four cages, actuated by two separate winding-engines, with cylinders 36½ inches in diameter and 6 feet 6¾ inches stroke. One winding-engine is compound, and the low-pressure cylinder has a diameter of 4 feet 3 inches. The cages have four decks, each deck containing two tubs with a capacity of about 11 cwts. The heapstead is arranged with a double banking-platform, the upper being connected with the lower deck by means of drop-cages. The nuts and small coal passing from the screens are conveyed to two Baum washers,

one on either side of the heapstead, and these have a capacity of 150 to 220 tons per hour respectively.

The ventilation is effected by two Geisler ventilators, one being held in reserve. These ventilators are 14 feet 9¼ inches in diameter, and exhaust 212,000 cubic feet of air per minute under a depression of 3·5 inches. In the same engine-house are four Dingler water-column air-compressors, capable of yielding together 424 cubic feet of compressed air up to a pressure of 5 atmospheres per minute.

The coking-plant comprizes two batteries, each of 60 Otto-Hoffmann ovens, and the bye-products are recovered at one battery, while the hot gases from the other are used for heating the boilers.

Fig. 10.—Miners' Baths at the Shamrock Colliery.

The baths for the miners are provided with 64 showers, and are capable of accommodating 3,200 men (Fig. 10).

An experiment was conducted to shew the efficiency of the Walcher-Giersberg pneumatophor, an improved life-saving apparatus. This apparatus differs from the original Walcher pneumatophor:—(1) In the substitution of dry alkali for caustic soda, which it was found in practice was dangerous, as it caused severe burns if any escape of the liquor from the breathing-bag took place, several workmen having been severely burned; and (2) in the introduction of an automatic regulating-valve between the oxygen-cylinders and the breathing-bag: it possesses the great advantage that the wearer has no occasion to trouble him-

self with the manipulation of the valve for the admission of oxygen. No helmet is used with this apparatus, as the helmet tends to make the head hot, and greatly hampers the workmen, as it is sometimes found exceedingly difficult to work with the helmet owing to the way in which it hampers the sight and hearing. Three workmen, wearing the Walcher-Giersberg apparatus, entered the experimental room at 10·0 a.m. and remained in an atmosphere, which had been made unbreathable by the burning in it of hair and other substances, until 11·45 a.m. During this time, the men were performing as severe labour as they would have had to perform had they been in a mine after an explosion. Mr. Meyer considers that, for the sake of experiment, the best way in which the men can exert themselves is by raising, by means of a rope passing over a pulley, a certain weight throughout the period of the experiment. This enables the actual amount of work done to be accurately ascertained, and it is doubtless no less fatiguing than climbing over falls, or carrying weights would be. The latter kind of work is done to a great extent during the usual practices. It will be observed from the foregoing statement that two of the men remained in the chamber, entirely dependent upon the apparatus for their respiration, for a period of 1¾ hours; the third man came out a little earlier, but this was due to the exhaustion of the oxygen in the supply-cylinders owing to a leakage in an apparatus made for experiments in the colliery-workshop.

SHAMROCK I. COLLIERY.

The seams lie at a high angle of inclination (about 80 degrees) and are won by cross-measure drifts, enabling a number of seams to be worked at the same time.

The method of working is by "overhand stoping" as commonly adopted in metalliferous mines. In the first level from the cross-cut, compressed air and percussive coal-cutting machines and power-drills are used; but in the higher or succeeding stopes, the cutting is done by hand. From the higher stopes, the coal is put down a pass into the main level, and filled into tubs from a shoot. In other places, the method of working adopted is almost the same as that employed in the

working of highly-inclined seams in North Staffordshire, the exception being that the lower endings or drifts are worked out back to the main rise in advance of the higher places, or in the opposite order to the North Staffordshire method.

A large quantity of slate or bind is taken out of the coal in washing the small, and this is all returned into the pit and used as stowing for packing the goaf.

The temperature in the workings is high, and reliance appears to be placed upon water-jets and small auxiliary compressed-air fans for the production of a ventilating-current at the working-face. The safety-lamps are of the Wolf benzine-type with a single gauze and no shield or bonnet; they are fitted with a magnet-locking arrangement, and contain a coil of friction-caps or igniters for relighting.

Fig. 11.—An Ambulance-room at Shamrock I. Colliery.

Difficulty is experienced in ventilating the many working-faces in the various seams from the different levels, and additional ventilation for the more distant headings and workings is obtained, as before mentioned, by small power-driven fans, and water-jets. A special plan, shewing the details of the ventilation, is drawn upon glass, and the volumes of air and ventilating arrangements are revised every day—taking up the whole time of one draughtsman. A sun-print of this plan is taken periodically for permanent reference. A graphic diagram is also kept, on which the downcast air is shewn split into the various seams, and into the main intakes and working splits of

each seam: the total number of air-splits from one downcast-shaft is upwards of 100. This diagram also shews the number of men and horses working, the number of lamps in each split, the number of cubic feet of air passing per minute, and the number of cubic feet passing per man: these figures are revised weekly. Samples of the return-air from the main return-airways are taken weekly for chemical analysis (made at the Bochum Mining School) and the results are recorded for permanent reference. The analyses shewed that the main return-airway contained 0·12 per cent. of methane and 0·5 per cent. of carbonic acid gas.

The telephone arrangements are very complete: the general manager's office being coupled to the office of each official, and to each pit; each landing of each pit is connected to the surface, and sets of portable telephones are stored so that they may be speedily run inbye to any distance. The manager is thus able to speak to the site of any accident or fire within 1 hour of its occurrence.

COKE-WORKS OF THE GUSTAV-SCHULTZ COMPANY.

The Kopper coke-oven may be described as a modification of the Otto-Hoffmann oven, inasmuch as the recuperator characteristic of that system is retained, but the gas is admitted at the bottom of the vertical flues, which form the sides of the oven, through fire-brick nozzles. Through these the gas passes, the air for combustion being admitted just above the nozzles through a diagonal passage, so that the combustion takes place at the bottom of the flue, and the flame passes directly upward. The difference between this oven and the Otto-Hilgenstock oven is that the mixture of the gas and air takes place in the flue itself, instead of in a Bunsen burner, and that the resulting heat is more intense. In the Otto-Hilgenstock oven only eight burners are used for each oven-wall, whereas in the Kopper oven, each flue forms its own independent burner. The air for combustion is heated to a temperature of 1,000° Fahr. as it leaves the recuperator, the flow of the gases is exceedingly simple and unconfined, and the heating of the oven-wall is perfectly uniform. In Figs. 4, 5 and 6 (Plate XXII.) A, A, show the recuperators; B, the pipes supplying the burning-gas, coming from the bye-product recovery-plant; C, the passage under the

oven-wall through which the gases are conducted to the burners, D, D; E, E, E, are the flues in which the gases are ascending; and F, F, F, the flues in which they are descending. The direction of the heated gases is reversed every ½ hour as in the Otto-Hoffmann oven, consequently when the direction is changed, the flues F, F, F, will be those in which the gases are ascending and E, E, E, those in which they are descending. The openings, G, G, G, at the top of the ovens enable the flues to be inspected, and, if necessary, the burners can be removed and changed through them. The efficiency of this oven is remarkable, the burning-time occupying only 26 hours, and the coke presents a bright silvery appearance. The hydraulic-main (Fig. 8, Plate XXII.) is of special design, and the upper part of the bent pipe can be removed to facilitate the cleaning of the valve, and the recovery of any pitch which may have accumulated.

RHEIN-PREUSSEN COLLIERY, RUHRORT.

These extensive collieries are the property of Messrs. Haniel, who possess mining rights over an area of 23,470 acres. There are three coal-drawing shafts, and two in course of sinking, finding employment for 3,500 men and 98 officials. The coal is loaded direct into boats on the river Rhine, and is sent by rail to the neighbouring industrial centres of Düsseldorf, München-Gladbach, Crefeld, etc.

The collieries are situated in the flat valley of the river Rhine, and the pits are sunk through a considerable thickness of Tertiary and Quaternary strata. The thickness of these Tertiary strata has been found to be about 420 feet in the south and 1,140 feet in the north. The surface-measures consist of beds of alluvial mud and sand deposited by the Rhine, possessing little coherency and full of water, the latter being evidently connected with the river. In sinking through such measures it is evident that the amount of water to be dealt with is almost unlimited, and it will be readily understood that under the most favourable conditions the shafts could only be sunk through such strata by means of boring machinery at enormous cost and under extraordinary difficulties. No. I. shaft only reached the Coal-measures, 20 years after the commencement of the sinking. The original diameter was 24 feet 9 inches

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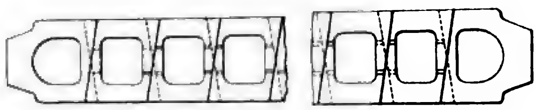
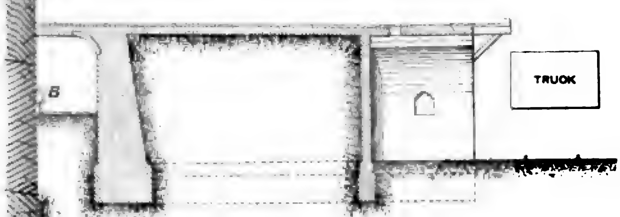
FIG. 7.—HORIZONTAL SECTION THROUGH THE OVEN-WALL.





Scale. 16 Feet to 1 Inch.

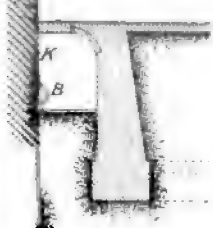
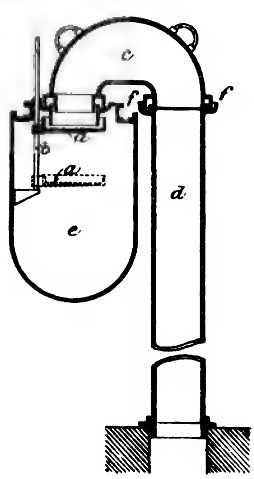
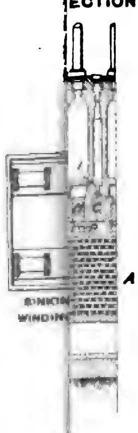


FIG. 8.—GAS CUT-OFF VALVE.



Sca

ECTION OF OVENS.



et to 1 Inch.

and the lining consisted of masonry, cast-iron and wrought-iron, until the diameter of the shaft was reduced to 8 feet 10 inches; while No. II. shaft, after 9 years' working, with an original diameter of 32 feet 5 inches and with linings of masonry and cast-iron was reduced to a diameter of 14 feet. Thanks, however, to past experience, No. III. shaft was sunk to the Coal-measures in 3 years with a diameter of 14 feet 9 inches.

The bad results attending the method of shaft-sinking with the Sack boring-apparatus, and the good results which have been obtained in deep borings with percussive borers, encouraged Mr. Pattberg to try a new method of shaft-sinking by boring at No. V. shaft. Its peculiarity consists in a percussive borer suspended from a rope and without a balance, capable of giving 60 to 70 strokes per minute with a stroke of 8 to 12 inches, coupled with the simultaneous use of water under pressure and the removal of the débris by means of compressed air. The borer receives its up-and-down motion from a reciprocating drum driven by a steam-engine. The gradual lowering of the borer, which hangs from the rope, during the boring-work is very precisely regulated and without expenditure of power, through spur-gearing connected with the rope-drum. The regulation of the rods is effected by means of a pneumatic accumulator. The loosening of the rock is performed by a percussive borer, which is so arranged that water under pressure is conducted through the hollow bore-rod to outlets adjacent to the cutting-edge on the under side of the borer, the jets from which wash the broken rock to the centre of the shaft. Two air-pressure pumps, which are secured to the borer, gather the broken material from the deepest point of the conical shaft-bottom and force it through a discharge-tube to the surface. The delivery of the sinking-dèbris at bank is effected by a specially-constructed flexible connection, as are also the pipes conveying the compressed air for working the air-lift pump and the pressure-water for scouring the bottom of the sinking. Warned by the unfortunate circumstances of last year, Mr. Pattberg has improved the construction of the shafts, in order to guard against unequal side-pressure, by the introduction of strengthening rings, spaced at regular intervals and strengthened by internal walling. This construction is described as "compound shaft-walling."

This arrangement is in operation at Nos. IV. and V. shafts,

and has answered exceedingly well. These two shafts have been bored through 480 to 510 feet of alluvial and Tertiary beds. The dimensions of both shafts are the same, so that the parts may be interchanged. The foundation-walls, 40 inches in thickness and 29 feet in internal diameter, are carried down to a depth of 66 feet through strong sand and gravel in order to hold back the pebble-bed. Then compound shafts 21 feet 4 inches in internal diameter and 25 feet in external diameter were adopted, and have reached depths of 195 and 243 feet respectively. In the case of No. IV. shaft, a concrete plug. 9 feet 10 inches thick, was bored through in six days; and a progress of 3 feet a day was achieved. The 153 feet of Tertiary strata were sunk through in 34 days, being at the rate of 4½ feet a day, and making an average progress of 4 feet 2 inches per day. In the case of No. V. shaft, 2 feet 8 inches through the concrete and 5 feet through the Tertiary beds was bored each day, giving an average depth of 5 feet 7 inches per day.*

The expectations which were formed of the effect of percussive boring with short strokes of 8 to 12 inches and 60 blows per minute, coupled with the simultaneous excavation of the rubbish through air-pressure, and the introduction of water under pressure through the borer for scouring the pit-bottom, have been fully realized. At these pits, as a matter of fact, the boring had often to be suspended, because the shaft-walling could not keep pace with it. The shaft has been deepened 16½ feet in 24 hours on several occasions, and about 8,500 cubic feet of material have been bored and raised to bank, from a shaft 25 feet 7 inches in external diameter. There is also the very satisfactory feature that the shaft has been kept absolutely vertical, which previously was not obtainable. The lining of the shaft is forced down by means of hydraulic rams, which are ranged round the shaft at a distance of about 4 feet one from the other. These rams press against the foundation-wall, and ensure that each portion of the shaft is forced down to an equal extent. Latterly, Mr. Pattberg has adopted tubbing-rings in lieu of masonry, with satisfactory results.

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* *Trans. Inst. M.E.*, 1903, vol. xxv., page 150, plate VIII.

NEUMÜHL COLLIERY.

This is a modern colliery, which has been at work for eight years, and is now raising 1,000,000 tons of coal per annum from two shafts. At the upcast shaft, which has an entirely enclosed pit-bank, there are four cages with two winding-engines. A compound horizontal winding-engine is drawing 1,500 tons per day from a depth of 1,500 feet, and is designed to wind from an ultimate depth of 2,500 feet. The high-pressure cylinders are 35½ inches in diameter, the low-pressure cylinders are 49¼ inches in diameter by 71 inches stroke, the drum is tapered from 21 feet 4 inches to 27 feet 10 inches in diameter, the winding-rope is 9⅞ inches in circumference, the three-decked cages weigh 4 tons, six iron tubs weigh 3 tons, 3 tons of coal are drawn per wind, and the time occupied is 1 minute.

PROSPER COLLIERIES.

The Prosper collieries are very extensive and well-equipped, although they have been working a considerable time. The bottom-level, from which coal is being drawn, is about 1,750 feet deep. The cages contain eight decks each, with one tub on each deck, and there are two sets of cages running in the same shaft at the same time. The cages, on account of their length, are made in halves and bolted together. There is a duplicate winding-engine and extra pulleys are fitted on the headgear, arranged so as to be common to both shafts; and in case of accident to either of the ordinary winding-engines, the cages can be detached from the ropes and attached to the spare ones on the duplicate engine, and coal-winding can be restored as usual within 2 hours.

The plant includes three winding-engines (two of which are fitted for winding on the Kœpe system), a large direct double-acting pumping-engine, three air-compressors, three electric-lighting plants, duplicate fan-engines, central condensing-engine for water-cooling plant, brickmaking plant in duplicate, two Baum coal-washing plants for treating 200 tons per hour, a Humboldt coal-washer for 150 tons per hour, 60 Kopper coke-ovens with bye-product recovery-plant, and 58 Collins coke-ovens with bye-product recovery-plant.

RHEIN-ELBE COLLIERY, GELSENKIRCHEN.

This is a new colliery, the shafts being completed in 1900 to the 2,300 feet level. The present output is 3,000 tons per day of 16 hours. The shaft is divided by a central partition, and, until a communication was made with No. I. and No. II. pits, it served for both upcast and downcast. A small portion of the upcast is again partitioned off for pump-mains, steam-pipes, etc. The downcast and upcast portions of the shaft are each provided with a complete set of winding apparatus, winding from different depths. The upcast winding arrangements consist of four-decked cages with two tubs on each deck. Keps are not in use at the surface. The winding-engine has two horizontal cylinders, 36 inches in diameter by 6 feet stroke, with a cylindrical drum 23 feet in diameter. A Baumann controller automatically regulates the speed by altering the cut-off, and prevents over-winding. The engine-house is an ornamental structure with stained-glass windows, curtains, tiled and carpetted floor, and walls decorated with both dado and frieze, and is kept clean and neat. The headgear is a steel, combined lattice-and-girder framing. It has a main frame (square in plan) immediately above it, on which are carried two sets of pulleys placed at right angles to each other. A framing, carrying a two-railed track for a travelling overhead carrier, is fitted above each set of pulleys, by means of which the pulleys may be lifted out of their seating and lowered direct to the ground-level or *vice versa* (Fig. 12).

Fig. 12.—Double Headgear at Rhein-Elbe Colliery.

A coal-washer, in course of erection, is designed to wash 120 tons per hour on the new Baum system. There are two compressed-air driven hydraulic jigs of different sizes. The coal, as it comes from the mine, will be washed on the larger jig, and the smaller jig will rewash the slack.

HOLLAND COLLIERY.

This is a large and well-equipped modern colliery. The horizontal bars of the screens revolve in the direction in which the coal travels. The shunting-locomotives have no furnaces, and the boiler or steam-reservoirs are charged when required from the colliery-boilers. The ventilation is effected by a Capell fan. There is a battery of 30 Otto coke-ovens and another of Collins ovens; and the gases from both batteries are led to a bye-product and tar-distillery, producing sulphate of ammonia, benzol, anthracene, naphthalene, lubricating-grease and pitch.

SHIP-LIFT AT HENRICHENBURG.

This interesting work, a new departure in canal-engineering, is capable of lifting boats up to 213 feet in length and 600 tons in weight through a height of 52 feet. A trough, 229 feet 8 inches long, 28 feet 3 inches wide, and 8 feet 3 inches deep, rests with iron structures on five cylindrical floats, which are completely immersed in wells, 30 feet wide and nearly 100 feet deep. The trough is really borne by two longitudinal girders, which run alongside its lateral sides, and by ties hanging down from them. In its ascent and descent, the trough is guided by four screws 81 feet 4 inches high and 11 inches in external diameter, the nuts of which are fixed to the trough. Each screw is crowned with a bevel-wheel, driven by bevel-gearing and shafts from the middle of a bridge, above the high reach. The driving shafts are thus about one-third of the length of the trough. There are two vertical compound steam-engines of 220 horsepower; one of them actuates the pumps which maintain the water-level in the high reach, and the other works the locks. Each engine is directly coupled to a continuous-current dynamo, yielding currents of 230 volts and 150 kilowatts at 150 revolutions per minute. A motor of 150 horsepower turns the screws. Normally both ends of the trough and both ends of the canal-

reaches are closed by shutters. When a ship is to be locked and the trough is to be raised, the heavy bolts which keep the shutters in position are withdrawn; then the two shutters, which face one another at the low reach, are coupled together. A small sluice is then raised on the trough-shutter at the low reach and the water is admitted into the chamber—the slot which is between the two shutters; that chamber is of course small, but it cannot be altogether avoided. The two shutters are now raised together, so that the boat may enter, and electric capstans move the boat if necessary. The lower edges of the shutters are, while the trough is open, about 15 feet above the trough-water level. The ship being secured in the trough, the shutters are lowered again by hand, and being counterbalanced, the work can be easily done by two men. The signal "up" is now given, and the screws begin to turn. When the trough has arrived at the high level, a man jumps over to the fixed structure of the high reach and reopens the doors. This operation—a single locking—takes 5 minutes. The descent is accomplished in the same time, and most of the time is, as in all such cases, spent in getting the boats in and out of the lock, as the actual rise or descent of the trough occupies only 2 minutes. The plant cost about £125,000, and the annual working expenses are rather below £1,000, including attendants' salaries.

BOCHUM MINING SCHOOL.

This school is now established in the new buildings erected at a cost of £54,000. Dr. Schultz, a member of the Prussian Parliament, the head of the staff, is supported by a numerous staff of professors. The number of students in attendance at the school is about 650, consisting chiefly of young men, who, having performed their military service, are desirous of becoming colliery-officials above or below ground; and from their ranks are recruited practically the whole of the official staff of the Rhenish-Westphalian coal-field. The curriculum includes thorough instruction in mining, geology, mineralogy, mining chemistry, surveying, mechanical engineering and electrical engineering. The entrance to the school is by examination. No fees are charged; the expenses being defrayed by the coal-owners, who raise the amount required by levying a small tonnage-rate. To enable students to attend

while engaged at the mines, instruction is given from 7·0 a.m. until 10·45 a.m. for those engaged on the evening shift; and from 3·30 p.m. to 7·15 p.m. for those engaged on the morning shift—a student entering one or other set of classes. Besides lecture-rooms, drawing-rooms, laboratories and museums, the school is equipped with a 250 tons rope-testing machine; and also with machinery for testing separate strands from ropes, in tension, torsion and bending; and further, with an exceptionally fine machine for testing anemometers. A pit, 100 feet deep, is used for giving lessons in diving: this subject is not compulsory, but it is invariably taken by students. A rescue-station is attached to the school, and regular drill is given in it.

In connection with the surveying-department, an observatory is established in the town-park; and meteorological and magnetic observations are automatically recorded. The magnetic variations are published by the school, and copies are sent to the mining-surveyors of the district.

At Consolidation III. colliery, a gallery for testing the behaviour of explosives in the presence of fire-damp and coal-dust has been erected by the school.

In connection with the chemical and physical department, much work is done for the collieries: for example, last year over 3,000 samples of air taken from the mines were examined for fire-damp and carbon dioxide, while many analyses were made of water, coal, coke, briquettes, boiler-scale, etc.

This successful excursion was arranged under the auspices of the Association for the Promotion of Mining Interests in the Dortmünd District, usually known as the Bergbauverein. The president, council and members of the Midland Institute of Mining, Civil and Mechanical Engineers (and particularly those who took part in the excursion) desire to express their sincere thanks for the admirable arrangements to the officers of the Bergbauverein, and especially to their representatives Bergassessor Schultz and Director Meyer. They also wish to thank the management of the collieries visited for the cordial and hospitable reception accorded to them.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

SAFETY-APPLIANCE FOR WINDING-ENGINES.

Sicherung des Förderbetriebes durch besondere Apparate. By A. Schlüter. *Glückauf*, 1902, *vol. xxxviii., pages* 444-452.

To reduce the pressure that has ordinarily to be overcome by the governors in releasing the stop-mechanism in safety-appliances for winding-engines, the author provides a horizontal governor controlling the movement of a rotable collar on a fixed guide-rod. To this collar is attached a disc carrying the pawl of the releasing-gear and capable of adjustment so that, when any given speed is exceeded in winding, the brake and cut-off gear of the engine is brought automatically into action. Should the cage be travelling too fast near the end of the trip, or be overwound, the collar is pulled round by a swing-hook actuated by a friction-bowl and adjustable sloping-planes on the back of the depth-indicator. This movement of the collar releases a check-pawl, which, in turn, releases a weight that actuates the throttle-valve and brake-mechanism. If the cage is gradually slowed down near the end of the trip, the collar does not come under the influence of the swing-hook. On the other hand, when the cage-velocity exceeds the maximum limit, the collar is pushed by the governor far enough to release the check-pawl, and actuate the cut-off and brake-gear. Two sets of pinions are provided for use in winding men and coal respectively, and the cage-velocity is shewn on a scale on the dial of the depth-indicator. C. S.

SAFETY-APPARATUS FOR WINDING-ENGINES.

Sicherheitsapparat für Fördermaschinen: System Wodrada. By Prof. K. Habermann. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., page* 227.

An apparatus has been designed by Mr. F. Wodrada to prevent the cages in mines from being wound too high, or raised too quickly. It is worked automatically by the winding-engine in such a way that if the cage be overwound, or the maximum permissible speed exceeded, the brake acts, and the admission of steam is cut off at the same moment. The apparatus is placed near the cage-indicator, and consists of two vertical racks placed behind the indicator-spindle, connected to each other and to a ball-governor. At the bottom of each rack is a pulley worked to and fro along a horizontal lever by the governor. If the speed of the engine (and of the governor) increases, the racks approach the indicator-spindle; if it falls, they recede. The position of a nut on the spindle corresponds with that of the two cages in the shaft. This nut carries a knife-edge which, if the normal speed

of the cage is exceeded, catches in the lower edge of the rack, and presses it down. A lever is thus set in motion, throws on the brake, cuts off the admission of steam, and the engine is stopped. It is also thrown out of gear if the proper speed is exceeded, and the cage wound up too quickly. The ball-governor then acts on the racks, and the knife-edge throws on the brake as before. To adjust the apparatus for different speeds of the cage without varying the sensitiveness of the governor, there are two pulleys of different diameters running loose on the motor-shaft, and connected to two others on the shaft of the governor. One or other set can be brought into play by a hand-lever. For winding up men, when the cage rises more slowly, the larger pulleys are used, and the smaller for winding up minerals. The racks also produce a gradual slackening of the speed as the cage ascends.

E. M. D.

THE FORMATION OF COAL.

Sur la Transformation des Végétaux en Combustibles Fossiles. By L. LEMIÈRE. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 502-520.

The author's main purpose is to show that there is complete analogy between the several phases of the manufacture of alcohol and those of the formation of coal, and, after marshalling in some detail the evidence which goes to support this assertion, he tabulates his conclusions much as follows:—

The principal factors in the transformation of plant-remains into fossil fuel are soluble ferments, living ferments, and antiseptic substances. The soluble ferments are not perhaps indispensable for the purpose of bringing about a certain degree of carbonization (they do not play much part, for instance, in the formation of peat); but when they are present they activate the process of maceration, that is the formation of the "fundamental pulp." The living ferments are the active agents of carbonization, while the antiseptic substances are necessary checks to gasification, and thereby save from complete destruction some portion of the vegetable mass.

Living ferments produced their maximum effect in the formation of anthracite, since that mineral contains as much as 95 per cent. of carbon. Soluble ferments give to ordinary coal its predominant characteristics: the formation of boghead and cannel-coals and of bitumens generally is traceable to the abundant supply of "vegetable jelly." In the case of lignites, the predominance of the several factors varied—sometimes the one, sometimes the other had the upper hand; and occasionally the antiseptic nature of the environing medium plays a considerable part, as in the case of xyloid lignites formed in sea-water. In peat-mosses, living ferments are abundant, but their action is rapidly modified by their own antiseptic products: apparently, soluble ferments are absent. Generally speaking, the formation of coal proper may be described as a diastasic and microbian process: the action of diastase corresponding to maceration, and the action properly so-called of the microbes corresponding to fermentation. The differences between natural fuels are assignable in part to the variety of vegetable secretions, and mainly to the varying proportions of the three factors already enumerated (soluble and living ferments and antiseptic substances). The amount of volatile matter present in a coal has nothing to do with its depth below the surface or with pressure, but depends on the nature of the plants and the microbes concerned in its formation. Similarly

the gases exuded from coal (fire-damp, carbon dioxide, etc.) are dependent on the same factors, but it is true that their retention within the seam or within its roof is conditioned by the more or less complete impermeability of, and the amount of pressure exerted by, the superincumbent strata.

There is no occasion for supposing that the plant-remains, before being buried beneath other deposits, underwent any other physical or chemical action than that which might take place as they were drifted along, for they brought with them all the factors necessary for their metamorphosis. Coal, then, need not have been formed before it was buried—in fact, it attained its definite chemical composition after the plant-remains of which it was made up were incorporated with other sediments. There is no question of considerable pressure, or of temperatures rising much higher than 140° Fahr.

Finally, each variety of fuel reaches a stationary condition at a certain point, at a time when the diastasic action is exhausted and the microbes have ceased to be. Save the intervention of external forces, peat arrived at its last stage will remain for ever peat; lignites will never become coal; nor coal anthracite. The plant-remains have passed from the vegetable into the mineral kingdom; time has accomplished its work, and in presence alone of inert matter embedded in a mass of other sedimentary deposits, it can never again exert any modifying influence, however long we may suppose time to last.

At all epochs, the determining course of the metamorphosis of plants into fossil fuel, the action of ferments on cellulose, has remained the same. Its "modality" alone varied through the ages (by which the author appears also to mean that the anthracite-producing microbe differed from the cannel-producing microbe, and so on). We may observe, however, that the author does admit that certain anthracites are metamorphosed coals.

L. L. B.

COAL-FORMING BACTERIACEÆ.

Du Rôle de quelques Bactériacées Fossiles au Point de Vue géologique. By B. Renault. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 646-663, *with* 13 *figures in the text and plates* vii. *to* ix.

Most of the recent forms of Bacteriaceæ—*Micrococcus*, *Bacillus*, *Streptococcus*, and *Streptothryx*—have been found in the fossil state at various geological horizons, in such animal and vegetable tissues as underwent mineralization before they had been very long exposed to the action of water and air.

The author describes and figures, as samples of the organisms preserved by silification, spherical masses of *Micrococcus* found in the pith of *Arthropitus* (an Upper Coal-measure plant), and various species of *Bacillus* occurring in *Pecopteris* and other ferns from the St. Étienne Coal-measures. The microscopic evidence leads him to infer that silicifying waters must have invaded the Coal-measure swamps or peat-mosses, and arrested the microbic decomposition of the plant-remains, which would otherwise have been completely destroyed.

Premising that boghead coals are the outcome of the accumulation of freshwater algæ at the bottom of small lakes, during periods ranging from the Culm to the Permian, the author points out that the species of the algæ, and sometimes the genus, varies according to the stratigraphical horizon and the geographical position. Thus, by mere inspection of a slide

under the microscope, he is able to determine whether a boghead comes from Autun or Kentucky, from Moscow or Armadale. The algæ were largely decomposed by the bacterial action of *Micrococcus petrolei*. The transformation of cellulose into boghead may be chemically defined as a practically-complete deoxidizing and partially dehydrating process:—

$$\underset{\text{Cellulose.}}{C_{12}H_{20}O_{10}} = \underset{\text{Boghead.}}{2\,(C_2H_3)} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{5\,CO_2} + \underset{\text{Methane.}}{3\,CH_4} + \underset{\text{Hydrogen.}}{2\,H}$$

Cannel-coals, on the other hand, are not simply (or mostly) made up of the remains of algæ, but more largely of the sporangia, etc., of club-mosses and ferns. Under the microscope they are seen to be permeated with myriads of *Micrococci*. The algæ vary from place to place, as in the case of the boghead coals.

Descriptions and figures are also given of the Bacteriaceæ which played so large a part in the formation of ordinary coal. It is reckoned that four-fifths of the original volume of cellulose was thus got rid of in the form of gases, while the remaining fifth represents the amount of coal formed. The process is expressed by the chemical equation:—

$$\underset{\text{Cellulose.}}{4\,(C_{12}H_{20}O_{10})} = \underset{\text{Coal.}}{2\,(C_9H_6O)} + \underset{\text{Methane.}}{14\,(CH_4)} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{16\,CO_2} + \underset{\text{Water.}}{6\,H_2O}$$

The author states that the foregoing formula for typical coal applies to a pure coal, whereas, of course, in many cases the gases of fermentation are in part still occluded by capillary attraction, etc., within the coal. He figures a microscope-section showing gas-cavities with contiguous masses of *Micrococcus* and *Bacillus* in coal, as illustrating this point.

He emphasizes in his conclusions the importance of the part played by Bacteriaceæ in the formation of coal, lignite, and peat, and draws once more attention to the fact that the nature of the vegetable matter operated on by the microbes has much to do with the quality of the fossil fuel produced.

The interest of the paper is much enhanced by the admirable illustrations which accompany it. L. L. B.

HUMIC AND OTHER COALS.

Charbons géloriques et Charbons humiques. *By* C. E. Bertrand. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 458-497.

The author is engaged on a series of detailed studies on fossil fuel of all kinds, but in this elaborate memoir he deals only with those types the history of which he believes to have worked out completely.

Under the heading of *gelosic coals* (coals of the "jelly" type) he classifies the kerosene-shales of New South Wales, the boghead coal of Autun, and the Torbane Hill mineral. The former two have been the subject of very complete monographs, but the last-named, he says, still awaits its monographer.

These three types result from the accumulation of algæ in a humic brown "jelly." He postulates further that the algæ were accumulated very rapidly, and that the fossilization of the jelly-like mass took place in the presence of bitumen. He gives a lengthy description of the structure and mode of formation of the Autun boghead and the kerosene-shale,

and then proceeds to deal with what he terms *humic coals*. As types of these he selects the Broxburn oil-shale, the Tertiary shale of Bois d'Asson (Basses Alpes), and the Cretaceous shale of Ceara in Brazil. He applies to bituminous shales the appellation of "humic coal" so long as the organic matter so predominates over the mineral matter as to give the "coal" its characteristic properties. He postulates that this kind of coal is formed from accumulations of brown "jelly," with which was associated a small quantity of spores, pollen, thalli of algæ, etc. (to the extent of about 4 parts in 10,000), and that the fossilization of this also took place in the presence of bitumen. In all cases, he considers that bitumen accounts for the occurrence of lamellæ of bright coal among bogheads and shales. Humic coals are the type of truly amorphous coal: they have a shale-like aspect, because their "fundamental jelly," readily combining with argillaceous matter, happened to be in contact with a sufficient quantity of such matter. Although he fully recognizes the importance of bacterial action in the case of *gelosic coals*, there does not seem to be any trace of the presence of Bacteriaceæ in the case of *humic coals*. Finally, he classes as *charbon de purin*, or *excretory coal* the bituminous shale of the Allier, which consists of a "coagulated brown jelly fossilized in the presence of bitumen." But in this case the brown "mother-liquor" was highly charged with excretory or stercorary substances. Reptilian coprolites occur abundantly in this shale, and associated with them are nodules of animal charcoal. Microscopic examination discloses the presence in this "excretory coal" of masses of bacteriform bodies, as also vegetable spores and pollen.

L. L. B.

BOGHEAD COALS FORMED FROM ALGÆ.

Sur quelques Algues Fossiles des Terrains anciens. *By* B. Renault. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, **1903**, *vol. cxxxvi., pages* 1340-1343, *with* 6 *figures in the text.*

All the boghead coals that the author has examined are made up of the bedded accumulations of algæ, the structure of which is well preserved.

The Autun boghead is made up of a globulous alga, *Pila*, a genus of which many species have been described by the author, characteristic of the Northern Hemisphere. The genus *Reinschia*, on the other hand, is characteristic of the Southern Hemisphere, and it is of species belonging to this genus that the Australian and Transvaal bogheads are made up.

The Armadale boghead is chiefly built up from the agglomeration of the thalli of an alga, which the author calls *Thylax Britannicus*, very diminutive in comparison with the genera mentioned in the preceding paragraph.

The bogheads of the Moscow basin are built up of a highly ramified alga, to which the author applies the generic designation of *Cladiscothallus*. The same genus is found in the North American bogheads.

The author maintains that each important deposit of boghead coal is recognizable or distinguishable by means of the particular genus of alga from which it is derived, and that the invariable presence of Bacteriaceæ on the walls of the cells of the algæ leads inevitably to the inference that these bacteria (*Micrococcus petrolei*) setting up a special fermentation, played an important part in the transformation of the cellulose of the algæ into fossil mineral fuel.

L. L. B.

FISSURE-VEINS.

Metasomatic Processes in Fissure-veins. By WALDEMAR LINDGREN. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 578-692.

The following is an abstract of the conclusions presented in this paper:—
Almost all fissure-veins are bordered by altered zones of varying extent and intensity of alteration. In replacement-veins, this altered rock contains the valuable ore.

Metasomatic processes vary in different classes of veins, quartz may be converted into calcite in one class, while calcite may be converted into quartz in another; the action is usually intense, and the chemical composition much changed. The hydration connected with the alteration is only very moderate. Potash-mica in some form is the most prominent mineral formed by the metasomatic processes: the most prominent process being the progressive elimination of soda and concentration of potash. Metasomatic processes in fissure-veins differ distinctly in most cases from those involved in static, dynamic and contact metamorphism; the two classes of change have not generally taken place under the same conditions and agencies; there are, however, some exceptions. Ordinarily, the alteration consists in the total or partial loss of some constituents; the gain of others; and the introduction of new compounds and elements, usually carbon dioxide and sulphur. The result may be a gain, or loss, per unit of weight or volume.

The processes observed can, generally, only be explained by aqueous agencies. The intensity shows that the aqueous solutions acted under moderately high temperature, pressure and concentration; no cold pure surface-water could have produced such results as are ordinarily found.

Since the substances introduced are only known to be contained in noteworthy quantities in thermal waters ascending through fissures, it is concluded that these waters were the active agencies in the process of alteration. Many of the substances found filling the open spaces along the fissure may be lacking in the altered rock, showing that the latter is not as easily penetrated by all the constitutents of the solution.

The ascending waters are chiefly surface-waters, which, after a circuitous route underground, have found, in a fissure, an easy path by which to return. During their downward passage, they dissolve material from the rocks which they penetrate, their power to dissolve being increased by the heat and pressure due to the depth. During the ascending period, much of this material is deposited. The metasomatic action on the wall-rock causes further exchanges of constituents, some being dissolved and others deposited.

Probably most fissure-veins are genetically connected with intrusive rocks, even when the deposits are contained in the overlying surface-lavas. Intrusive rocks may contain carbon dioxide, water, sulphur, etc., at the time of their intrusion. Under decreasing pressure, these substances tend to leave the cooling magma; and as many of them form, with the heavy metals also contained in the magma, volatile compounds with a low critical temperature, these heavy metals may be carried away from the magma along with the mineralizing agents mentioned above. The result of these emanations is seen in contact-metamorphism and in the mineral deposits so often appearing near the boundaries of intrusive bodies. Where fissures traverse the cooling magmas, and the rocks surrounding them, it is natural that these mineralizing agents carrying their load of heavy metals should

ascend above the critical temperature, and on reaching the zone of circulating atmospheric waters it is natural that they should mix with them. To this combination of agencies, found in the ascending waters of such regions of igneous intrusion, the formation of most metalliferous veins is probably due. Some classes of veins may be due to circulating surface-waters alone; but it is incredible that the dissolving power of the latter is sufficient to account for all classes, or even for the majority, of fissure-veins.

A. W. G.

ORE-DEPOSITS.

Origin and Classification of Ore-deposits. By CHARLES R. KEYES. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 323-356.

The accompanying scheme tabulates the groups and categories of ore-deposition with the general forms of ore-bodies recognized by miners:—

Groups.	Categories.	Miners' Forms.
I. Hypotaxic: mainly surface deposits.	Aqueous transportation. Residual cumulation. Precipitative action.	Placers. Pockets (in part). Bog-bodies, some beds, layers.
II. Eutaxic: chiefly stratified formations.	Original sedimentation. Selective dissemination. Emponded amassment. Fold-filling. Crevice accretion. Concretionary accumulation Metamorphic replacement.	Beds, strata, layers. Impregnations (in part). Masses (in part), some segregations. Saddle-reefs. Gash-veins, stockworks (in part). Nodules. Fahlbands (in part), beds.
III. Ataxic: predominantly unstratified and irregular bodies.	Magmatic secretion. Metamorphic segregation. Fumerole-impregnation. Preferential collection. Fissure-occupation.	Masses (in part), some lenses. Stocks, lenses. Contact-veins. Chambers (in part), some pockets, linked-veins. Attrition-veins, true veins, some linked-veins.

A. W. G.

THE PART PLAYED BY TITANIUM IN MINERAL-DEPOSITS.

Le Rôle du Titane en Géologie. By L. DE LAUNAY. *Annales des Mines*, 1903, *series* 10, *vol. iii., pages* 86-105, *with* 2 *figures in the text.*

Pointing out, first of all, two essential facts which characterize the chemical properties of titanium, namely, its analogy on the one hand, with iron; and, on the other, with the group of silicon, tin, zircon and carbon, the author proceeds to consider the most important occurrences of the metal. Hundreds of deposits of titaniferous iron-ore are known in Scandinavia, Finland, Canada and the United States, and Brazil. These all occur as masses in the midst of basic igneous rocks, mostly gabbros: three only

being in nepheline-syenites, those of Alnö, São Paulo, and Magnet Cove (Arkansas). As a general rule, where ferruginous segregations do occur in acidic rocks, titanium is all but absent. On the other hand, it will be observed that chrome-iron-ore and platinum are the characteristic metalliferous occurrences in peridotites. In these the olivine is generally of later crystallization than the chrome-iron-ore, whereas the titaniferous ore, in the rocks where it occurs, encases the other constituents, showing that it was of later consolidation than they.

Viewing eruptive rocks as a whole, they generally contain about 0·32 per cent of titanium compared with 4·5 per cent. of iron; but in gabbros, the titanium has consolidated faster than the iron, and the comparative proportion increases to 1 in 10 or 12; in titaniferous iron-ores the proportion is 1 to 5 or 7·5.

Postulating that one of the essential phenomena of vulcanicity, however deep-seated, is the introduction of surface-waters by means of the dislocations brought about by folding of the earth's crust, the author considers that this water acting on the carbon, which is most probably one of the fundamental elements of the deep-lying magma, has given rise to hydrogen carbides, and these in turn to carbonic acid, which, either free or associated with alkalies, has been the essential agent in the formation of many of the minerals characteristic of metalliferous veins.

Some little space is devoted to the consideration of titanium-minerals in acid rocks, but it does not appear that these are of great economic importance. L. L. B.

EXPERIMENTS ON THE PERMEABILITY OF CLAY.

Quelques Expériences sur la Perméabilité de l'Argile. By W. SPRING. *Annales de la Société géologique de Belgique*, 1901, *vol. xxviii.*, *Mémoires*, *pages* 117-127.

The author set himself out to determine experimentally under what conditions water will pass through a stratum of clay, and whether this passage is possible in nature. He took plastic grey clay from Andenne, which contains very little sandy matter: in the completely dry state this clay has a specific gravity of 2·62, but when it has been kneaded up with 17 per cent. of water, its specific gravity is only 2·05—that is, the volume of clay is simply increased by the volume of water added to it. The question then arises whether the swelling of the clay is not a necessary condition, as well as a consequence, of the penetration of water; in other words, whether a clay mechanically prevented from expanding would be permeable to water. The author then proved by experiment that a mass of clay, which was allowed to expand freely, absorbed about seven times as much water as a similar mass of clay, which was prevented from expanding: in other words, 15·65 per cent. as compared with 2·67 per cent.

On the other hand, he ascertained that a mass of clay kneaded up with 33 per cent. of water could, if sufficiently compressed, be made to yield up a large quantity of the contained water, even if kept under water. He made use of a piston which exercised a pressure of about 42 pounds per square inch (3 kilogrammes per square centimetre) during three days, and at the end of that time it was found that the clay had given up 30 per cent. of the contained water. Then the experiments were varied, by making the clay more and more watery, till about 70 per cent. of its total volume

was water; but, however the proportion was varied, the quantity finally retained by the clay after compression was practically the same in all cases, that is 27 per cent. roughly. On increasing the pressure, however, to as much as three times that above-mentioned, about 4 per cent. more water was eliminated.

The author made further "imbibition-experiments" with gelatine, starch, and loam from the plateau of Hesbaye, and found that all these substances resembled clay in their comparative refractoriness to water-percolation or absorption, if prevented from expanding freely. The proportional percentages are, however, very different.

One conclusion which will appear fairly obvious is, that the deeper a clay-bed lies below the surface, the greater is its state of compression from the superincumbent weight and the more restricted will be the possible range of percolation of water. L. L. B.

SALINE WATERS IN THE FRANCO-BELGIAN COAL-MEASURES.

Sur les Eaux Salines des Nappes Aquifères du Nord de la France. By Jules Gosselet. *Comptes-rendus du huitième Congrès géologique international,* 1900 [1901], *pages* 383-385.

Many of the deep borings in the north of France yield waters containing sodium chloride (salt) or sodium carbonate, and yet these borings traverse only strata, such as chalk, limestone and sandstones, that contain no sodium-compounds. The presence of sodium appears to be connected, on the whole, though not universally, with the depth of the boring. The question is as to where it comes from: no saliferous Triassic deposits have been struck in this region, and the hypothesis of infiltration from rain-water is also excluded. Two suppositions appear to the author admissible: (1) that we are dealing here with the remnants of the waters of ancient seas; and (2) that water from the present ocean-bed is forced by pressure into the permeable strata underlying it, and then gradually percolates downward.

However that may be, we cannot lose sight of the fact that the waters pumped from the Coal-measures of northern France and Belgium contain sodium in three combinations:—chloride, carbonate and sulphate. The chloride is characteristic of the water which properly belongs to the Coal-measures, and has not been exposed to mixture with water from other sources. The carbonate indicates a mixture of the true Coal-measure waters with those which have percolated down from the surface through the Chalk. The presence of sulphate is traced to the band of pyritous shales, which occurs at the base of the Westphalian series, and is worked around Liége for the manufacture of alum. Consequently, sulphated waters indicate that one is getting near the base of the workable Coal-measures, near limestones which are considerably jointed and hold a large volume of water. Therefore, mining-engineers in the Franco-Belgian coal-field regard waters containing sulphates as carrying with them a sort of warning, and constituting, it may be said, a danger-signal. L. L. B.

THE EARTHQUAKE IN NORTHERN BAKONY, HUNGARY, 1901.

Über das Erdbeben im nördlichen Bakony vom 16. *Februar*, 1901. *By* DR. FRANZ SCHAFARZIK. *Földtani Közlöny*, 1901, *vol. xxxi., pages* 184-186, *with a map in the text.*

This earthquake took place about 5 p.m. on February 16th, 1901, in Northern Bakony, the name given to an area which stretches over part of the two contiguous counties of Veszprém and Györ. The inhabitants were terror-stricken, and yet no serious damage was suffered. The report from Gicz, a village in the epicentral area, states that shortly after 5·17 p.m. on the day mentioned, a violent shock, travelling from north to south, was felt, and lasted about 5 seconds. It was accompanied by loud rumbling, the houses seemed to oscillate, and ominous cracks were heard. The villagers rushed out into the road, in the belief that the roofs were falling in. Chandeliers were set swinging, and so forth; yet no clock was stopped, and no fissures were observed in the house-walls. Similar accounts came in from the farmsteads of Romány, Tamási and Varsány. No premonitory symptoms were shown by birds, domestic animals, etc., and there was nothing abnormal about the weather. One observer, however, states that at 3·15 p.m. a sort of explosive crash was heard, no cause for which can be traced. The violence of the shock at Gicz corresponded to 6 in the De Rossi-Forel scale. Beyond the epicentral area, the earthquake appears to have travelled with greatest facility along a line running from north-north-west to south-south-east, through Zircz, etc. Transverse faults are known to occur in great number in the Bakony basement-rocks (along the northern margin of which the epicentrum lay); and it is probably along one such fault-fissure, which happens to be intercalated among those previously known, that the earthquake found the line of least resistance to its propagation. The origin of the shock is, however, believed to be a tangential rupture defining the north-western margin of the Bakony massif. L. L. B.

EARTHQUAKE IN SOUTHERN HUNGARY, 1901.

Das Erdbeben in Südungarn vom 2. *April*, 1901. *By* FRANZ LAJOS. *Földtani Közlöny*, 1902, *vol. xxxii., pages* 322-325, *and* 1 *plate.*

About 6 p.m. on April 2nd, 1901, an earthquake took place, the effects of which were felt over about ten counties in Southern Hungary and over a large portion of Servia as well, that is, over an area of some 28,000 square miles. It had been preceded by various premonitory shocks, between March 26th and 31st, and was followed by after-shocks up to April 8th. Records were obtained from observers in 171 different localities.

The earthquake was among the most considerable that had taken place in Hungary since the eleventh century. The area mapped out by the isoseismal curves has an ovoid form, the longer diameter striking north-north-west and south-south-east and measuring about 200 miles; while the shorter diameter runs from east-north-east to west-south-west, and measures some 185 miles. This last is coincident in direction with the major axis of the epicentral area. The epicentral area (952 square miles) is of very irregular form. Within it about 40 buildings were reduced to ruins, and 300 chimneys crashed down. The violence of the shock lay between 6 and 7 degrees on the Forel scale, and its effects were most destructive along the banks of the Béga and Temes rivers. Indeed the original focus of the earthquake is

believed to have lain somewhere below the Béga valley, and here two persons lost their lives.

Outside the epicentral area, lies one of ellipsoidal form, covering some 2,470 square miles, within which some slight damage was done, the violence of the shocks ranging between 5 and 6 degrees of the Forel scale. Outside that again, areas of diminishing seismic intensity are plotted out, and it is noticeable that this intensity decreased far more slowly southward than in any other direction.

The main shock lasted, according to the locality where it was felt, from 1 to 10 seconds, and was accompanied by a subterranean rumbling, variously likened to distant thunder, the rush of a railway-train, the clattering of a heavy-laden dray, etc. The velocity of propagation is reckoned to have been about 1,000 feet per second.

The area affected is largely covered with deposits of loose texture (drifts and alluvia), below these come the Levantine and Pontic formations, and below these again the highly-fractured *massifs* of older rock. A fault-fissure is known to coincide with the strike of the Béga valley, and it is presumed that the earthquake was due to the sagging of rock-masses along this line.

L. L. B.

SEISMIC DISTURBANCES IN BELGIUM IN MAY, 1902.

Sur les Mouvements sismiques et les Perturbations magnétiques du Commencement de Mai, à la Station d'Uccle (Belgique). By EUG. LAGRANGE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 1325-1327.

The author points out that, on the whole, seismic activity has become more marked on the surface of the globe since the beginning of 1902. He then shows that the Von Rebeur-Ehlert triple horizontal pendulum, set up at the Uccle geophysical observatory in Belgium, registered several considerable earth-tremors in the first fortnight of May (a fortnight which will be rendered ever memorable by the St. Pierre and St. Vincent catastrophes). Thus, on May 6th, shortly after 3·15 a.m., a diphasic disturbance began, the entire duration of which may be reckoned at 40 minutes. It seems to have originated in the depths of the western Mediterranean, off the coast of Spain, and to have travelled at the rate of almost exactly 1 mile per second. Tremors of less consequence had been numerous between May 1st and 6th, while from the 6th to the 8th, there was an interval of absolute quietude. On the 8th, however, at 2·47 a.m., a seismic disturbance far more considerable than any of the preceding made itself felt: the two periods of short and long undulations respectively being well marked, and the former phase lasting for 33 minutes. The general effect was that of an earthquake, the focus of which lay at a great distance. It was possibly connected with the Martinique eruptions, but certainly not with the great outburst of Mont Pelé which overwhelmed St. Pierre at a time equivalent to a few minutes after noon in North-western Europe.

The author has made comparative studies of magnetic perturbations and seismic movements, and so far the results obtained appear to confirm the conclusions of the Krakatoa Commission, that there is no effective association between the two orders of phenomena.

L. L. B.

EARTHQUAKES IN BAVARIA.

Beiträge zur Erdbebenkunde von Bayern. By Dr. JOSEPH REINDL. *Sitzungsberichte der Mathematisch-physikalischen Klasse der königlichen Bayerischen Akademie der Wissenschaften zu München,* 1903, *pages* 171-204, *with* 3 *figures and a map in the text.*

The author first of all describes the earthquake which took place at about 1·20 p.m. on November 26th, 1902, in the frontier-districts of Bavaria and Bohemia. The shock was recorded by the Wiechert seismometer in the Leipzig observatory, and lasted altogether 1 minute and 52 seconds: the total area over which it was felt measured about 1,545 square miles. In the area where it reached its greatest intensity, this is estimated to have corresponded to 5 in the De Rossi scale or 6 in the Forel scale. Houses quaked, church-bells were set ringing, mortar fell from the walls, objects placed on tables, benches and stoves tumbled down, and some walls were cracked. Prof. Credner believes that the seismic phenomena extended in reality over a greater area than that above mentioned. The direction of the shock was apparently from south-west to north-east, and the cause is attributed to tectonic movements in the highly-faulted complex of rocks of which that portion of the earth's crust consists.

The author then gives a catalogue of earthquakes in Bavaria, from 1008 A.D. up to 1903, supplementing the catalogue drawn up by the late Prof. Von Gümbel. Thereupon follows a description of the earthquake which occurred on January 25th, 26th and 27th, 1903, in the Bavarian Palatinate. The epicentrum lay somewhere below the village of Kandel. On the first day (Sunday, 25th) three violent shocks were felt at 9·45 a.m., 1 p.m. and 3·15 p.m. respectively; four on the second day, at 12·30 a.m., 7 a.m., 7·5 a.m. and 4 p.m. respectively; and three on the morning of the third day: they were accompanied by a rumbling as of thunder. No damage of any importance was occasioned by these shocks, but they caused much disquiet among the villagers and the stalled cattle. The direction of travel of the earthquake was from south-west to north-east, and its determining cause is no doubt to be sought in sagging movements connected with the great Rhenish Rift and the associated fault-fissures.

On March 22nd, 1903, the luckless village of Kandel was again the epicentral locality of one of the most considerable earthquakes that has ever occurred in the Palatinate. A premonitory shock was felt at 7·45 p.m. on March 21st; this was followed the next morning and afternoon by five violent shocks: chimneys crashed down, walls and ceilings were fissured, and a shower of plaster fell from them. The undulatory motion of floors and walls was very perceptible to the eye. After-shocks were observed on March 26th and 27th. The duration of the principal shock can hardly have exceeded 4 seconds. Signs of great fear were shown by all domestic animals. It is noteworthy that earth-tremors were recorded at the same time in Italy, the South of France, and the South of England, and that the Soufrière of St. Vincent was again erupting.

An extensive tract of North-eastern Bavaria was involved in the earthquakes which took place in the mountains of the Erzgebirge, Fichtelgebirge and the neighbouring Bohemian Forest on March 5th and 6th, 1903. Preliminary tremors had been observed on and about February 20th. The epicentral locality was Asch, a Bohemian town close to the Bavarian frontier: here seven violent shocks occurred on the morning and evening of March 5th, and the morning and afternoon of the next day. People ran in terror from their houses into the streets, chimneys fell down, cracks opened up in the walls, the electric light went out in many buildings. The intensity was

reckoned as 7 in the Forel scale at Asch, and as 6 in several other localities. The general direction of travel was from south-west to north-east, and the cause is attributed to tectonic movements taking place in the highly-faulted and fissured rocks of that area. It is, indeed, a region which has been over and over again visited by earthquakes.

Dr. Knett considers the last-described earthquake as belonging to one of the periodic "earthquake-swarms," caused by the pressures acting from the Alps in the south-east on the Bohemian *massif*: the Erzgebirge plays the part of a sort of seismic accumulator, and once a certain limit of tension is reached these accumulated pressures are released in the form of earthquake-swarms. The next batch should have been looked for, on this hypothesis, between the years 1950 and 1975, but the complication introduced by the "swarms" of 1900 and 1901 leads to the conclusion that a depression is gradually forming, transverse to the strike of the Erzgebirge, the full effects of which may not be felt for thousands of years to come. L. L. B.

"EARTHQUAKE-SWARMS" IN SAXONY AND BOHEMIA, 1900-1902.

Die Vogtländischen Erderschütterungen in dem Zeitraume vom September, **1900**, *bis zum März*, **1902**, *insbesondere die Erdbebenschwärme im Frühjahr und Sommer*, **1901**. *By* HERMANN CREDNER. *Berichte der Mathematisch-physischen Classe der königlichen Sächsischen Gesellschaft der Wissenschaften zu Leipzig*, **1902**, *pages* **74-90**, *with two maps in the text.*

After a brief description of the earth-tremors recorded at various localities in the Vogtland (Saxony) between September 19th, 1900, and February 13th, 1901, the author proceeds to consider the "earthquake-swarms," consisting of not less and perhaps more than 106 separate shocks, which visited the southern portion of that district between May 8th and June 28th, 1901. The most violent shock was felt on June 2nd at Brambach and Schönberg: the ground appeared to heave and sink, windows clattered, the birds flew in alarm out of their nests, and a noise like thunder accompanied the shock. This "subterranean thunder" was a characteristic accompaniment of many of the other tremors.

Only a few weeks of tranquillity intervened before another "earthquake-swarm" visited the same district, but extended this time into the Egerland (Bohemia). It began with a fairly violent shock at 1·50 p.m. on July 25th, 1901, of seismicity 5 in the earthquake-scale, travelling from north-west to south-east. The heaving of the soil, the quaking of walls, the clattering of windows, and the displacement of small articles of furniture were reported from the whole of the epicentral area. About 15 after-shocks were recorded up to the afternoon of August 31st. Then, for a period of several months, there was complete tranquillity, broken on December 8th and 9th by two very sharp shocks accompanied by a roar like thunder. These were recorded at Markneukirchen on the 8th at 10·45 p.m. and on the 9th at 5 a.m.

It is characteristic of the earthquakes that have befallen the Vogtland of late years that they occur so frequently in "swarms." Further, that the epicentra, instead of lying in the central and northern districts broken up by the most complicated tectonic disturbances, are situated in the southern district which is comparatively untouched by faulting and folding. In this district two independent foci are recognized: (1) that of Brambach-Schönberg; and (2) the other, that of Graslitz-Untersachsenberg; and the epicentral areas are situated either on granite or on the slates which abut directly on the granite. L. L. B.

THE EARTHQUAKE AT SALÓ, NORTHERN ITALY, 1901.

Sulle Condizioni geognostiche del Territorio di Salò (Prov. di Brescia) rispetto al Terremoto del 30 *Ottobre*, 1901. *By* L. Baldacci *and* A. Stella. *Bollettino del Reale Comitato Geologico d'Italia*, 1902, *vol. xxxiii., pages* 4-25, *and* 3 *plates.*

The authors made a careful examination of the geological structure of the district of Saló, a town which lies on the shores of the Lake of Garda, in the province of Brescia, with the view of determining to how great an extent this structure was a factor in the earthquake which took place there on October 30th, 1901, at 3·48 p.m. The region is subject to fairly-frequent seismic disturbances, but the shock just mentioned is said to be the most violent known to history on the "Riveria Bresciana." The earthquake was preceded by a rumbling as of thunder, and the motion, at first up-and-down, became undulatory, travelling in a direction from south-east to north-west, the duration being 7 seconds. No less than 16 after-shocks followed, the latest on January 9th, 1902, when the authors themselves were staying in the district. Scarcely a single building escaped damage, the greatest havoc being wrought in the flat strip along the lake-shore where the edifices, public and private, for some distance were ruined beyond repair. Half-way up the hillside the damage is considerably less, and it turns out in fact to bear a distinct ratio to the stability or instability of the deposits on which the city and suburbs are built, as well as to the solidity of the buildings themselves. The intensity of the earthquake was hardly so great as the destruction wrought by it would seem to imply, the authors estimating it at somewhat less than 8 in the De Rossi-Forel scale.

The strip along the lake-shore consists of fluvio-glacial deposits; overlying these, and forming the subsoil of the higher part of the city and immediate suburbs, are Quaternary argillaceous drifts. (It will be observed that all these deposits are practically loose detritus.) The solid rock-ridge behind consists of calcareous shales and conglomerates of respectively Cretaceous and Miocene age. Upon this ridge is perched the hamlet of San Bartolomeo, built on a patch of fossiliferous Pliocene clays, and the flanks of the ridge are mantled by a loose rubble of weathered rock. L. L. B.

THE EARTHQUAKES OF GREIZ AND THE BÖHMERWALD, 1902.

Die vom Wiechert'schen astatischen Pendelseismometer der Erdbebenstation Leipzig während des Jahres 1902 *registrirten Nahbeben. By* H. Credner. *Berichte der Mathematisch-physischen Klasse der königlichen Sächsischen Gesellschaft der Wissenschaften zu Leipzig*, 1903, 21 *pages*, 1 *plate, and* 3 *text-figures.*

On May 1st, 1902, at Greiz, in the Vogtland district of Saxony, an earthquake took place, the microseismic undulations of which travelled northward beyond Leipzig, and were recorded by the Wiechert astatic pendulum-seismometer in that city. The starting-point of the phenomenon appears to have lain in the highly-disturbed and faulted older Palæozoic belt which trends north-eastward through Zeulenroda, Greiz, and Berga from Pausa-Schleiz, finally disappearing below the Rothliegende formation of the Erzgebirge basin and the Gera district. The seismic phenomena manifested themselves along the strike of this older Palæozoic belt south-westward, but more especially north-eastward, dying out finally on the further side

of the Pleisse valley. The area thus affected was roughly elliptical, with a major axis about 19 miles in length, and a minor axis running east and west, about 12¼ miles long—say, in all, 181 square miles. A fairly violent shock, accompanied by a rumbling like thunder, alarmed the inhabitants of Greiz about 5·31 a.m. Doors and windows rattled, houses quaked, and tardy sleepers were all but shaken out of their beds. A second and a third shock followed, of diminishing intensity and shorter duration, as compared with the first. Judging from the record obtained by means of the Wiechert seismometer, the entire duration of the phenomenon does not seem to have exceeded 30 seconds, and no ascertainable damage was done to persons or property.

After discussing at some length the records obtained with the above-mentioned instrument, the author proceeds to describe the earthquake which took place early in the afternoon of November 26th, 1902, in the Böhmerwald (or Great Bohemian Forest) district. The roughly elliptical area affected by this earthquake extends over some 1,544 square miles, the major axis (about 56 miles in length) lying parallel to the main mountain-range. The epicentral area lies in the gneiss and granite-massif of the Böhmerwald, but the geological map fails to reveal any important fault-fissures or dislocations hereabouts, with which the seismic phenomena might be genetically associated. The exact time at which the tremor began was 1·19 p.m., and it reached an intensity (in the pleistoseismic area) of 5 in the De Rossi scale. Bricks fell from chimney-stacks, walls were cracked, houses quaked from roof to basement, doors flew open; in some places people ran out into the streets, and all domestic animals showed signs of great terror. Only one shock is reported in this area, and it was accompanied by a thunderous roar. Farther away from the epicentrum, instead of one shock, the records tell of 2, 3, or 4 undulating tremors lasting several seconds each, and of sufficient violence to give rise to considerable alarm. The entire duration of the phenomenon, as registered by the Wiechert seismometer, was little short of two minutes. L. L. B.

SEISMIC DISTURBANCES IN GREECE DURING 1899.

Résultats des Observations sismiques, faites en Grèce pendant l'Année 1899. *By* D. EGINITIS. *Annales de l'Observatoire National d'Athènes*, 1901, *vol. iii., pages* 21-27.

The number of earth-tremors recorded in Greece during the year 1899 was 567, exceeding the annual average by 36. This annual average is calculated from the records obtained during the quinquennial period 1893-1898. The frequency of the earth-tremors varied considerably from month to month, the maximum of 119 being observed in March and the minimum of 18 in December. The seasonal variation in number was as follows: 149 shocks in the winter, 271 in the spring, 62 in the summer, and 85 in the autumn. Out of the total 567 shocks, 348 took place during the night and 219 during the day. The records of 1899 confirm the conclusion drawn by the author from the observations made in 1893-1898, that there is no tangible relation between the frequency of seismic disturbances and the position of the moon in its orbit. The same remark holds good in regard to seismic phenomena and the periods of aphelion and perihelion.

A full list is given of the districts and towns or villages where the above-mentioned 567 shocks were observed. Zante would appear to be especially

"favoured" in this respect, no less than 421 out of the total number having been recorded there.

On the morning of January 22nd, 1899, at 12 minutes to 10, the province of Triphylia, on the western coast of Peloponnesus, was visited by an earthquake, which caused a considerable amount of damage, although its effects were, comparatively speaking, local. In the epicentral area at Cyparissia alone 53 houses crashed down, 70 others were rendered uninhabitable, and not a single house escaped damage. The phenomenon consisted of two violent shocks, both of which were preceded and accompanied by a subterranean rumbling. The second, instead of being undulatory in character, as was the first, was jerky in character, and was the one that caused most of the material damage. Each shock lasted about 7 seconds. The direction of travel was from south-west to north-east, almost perpendicular to the major axis of the epicentral ellipse. After-shocks continued for a week after the principal phenomenon. Domestic animals, such as dogs and chickens, showed signs of fear before the earthquake took place, uttering cries of alarm and seeking safety in flight. Prof. Milne's record of the shock, as observed by means of his instruments at Shide, in the Isle of Wight, showed that it travelled thither at the rate of 1¼ miles per second. There were no crevices or fissures opened up in the ground within the epicentral area, although subsidences, which compromised the stability of the railway-line, took place at Calamata. As usual, springs were variously affected in different localities, some drying up, others becoming turbid or flowing in greater volume. The complete "earthquake-catalogue" for 1899, in Greece, on which the author's memoir is based, occupies pages 336 to 375 of the *Annales*.

L. L. B.

THE EARTHQUAKE AT MIGNANO, ITALY, 1902.

Il Terremoto di Mignano (*Giugno-Luglio*, 1902). *By* V. SABATINI. *Bollettino del Reale Comitato Geologico d'Italia*, 1902, *vol. xxxiii., pages* 178-198, *and* 1 *plate.*

This memoir embodies the results of the investigation conducted on the spot by the author, at the request of the Minister of the Interior. The buildings at Mignano are generally of such poor materials and so execrably put together, that the very fact that they have not been reduced to a heap of ruins by a succession of earth-tremors extending over forty days or so, shows (in the author's opinion) that those tremors cannot have been of a very serious character. The motion, too, must have been mainly "up and down," rather than undulatory.

The first plainly perceptible shock was felt at 7·30 a.m. on June 24th, 1902, and another followed about 11 a.m. After an interval of several days of complete quietude, there came a series of after-shocks, from two or three to six or seven in a day, generally between 10 and 11 a.m., then at 11 p.m., and finally between 1 and 2 a.m. It is stated (whatever that may mean) that "the strongest shocks were generally felt on the night which followed on a Sunday!"

About July 4th or 5th, thunderous subterranean rumblings began to be heard, sometimes associated with earthquake-shocks, sometimes not. The inhabitants were panic-stricken on the night of Sunday, July 20th, when the earthquake-roar is described as unceasing and the shocks as continuous. About a week later, at 1·3 a.m. on Monday, July 28th, was the strongest

shock of the whole series. The last noticeable tremor seems to have taken place on July 31st.

The valley in which Mignano (province of Caserta) lies runs from north-west to south-east, up from the lowlands of Rocca d'Evandro into the hills of Mesozoic and Kainozoic limestone, which form its eastern and western walls. The valley is about 6¼ miles long, and through it is carried the railway-line from Rome to Naples. The valley-bottom is made up of volcanic materials overlying limestone, and Mignano itself is built on tuff. An ancient lava-flow, 1¼ miles in length and half a mile broad extends from south-west to north-east down towards the railway from the base of Monte Friello. There are other lava-flows in the neighbourhood, of apparently less importance.

On the geological map, which accompanies the memoir, the author has traced the isoseismal curves, and these show that the epicentral area has a roughly triangular form, one of the angles being ½ mile north of Mignano, and the other two distant about 2 miles respectively, south-south-west and south-south-east of that place. Evidently the seismic focus lay at no great depth, comparatively speaking. The author calculates it roughly at 5,000 feet.

In the case of most earthquakes that take place in Italy the strongest shocks are felt at the beginning of the period of seismicity, but at Mignano, as we have seen, particularly violent shocks were observed at the middle and at the end of that period as well.

The various possible causes of the Mignano earthquake are discussed, but the author prefers not to pin himself down to a definite opinion until such time as the tectonic geology of the area is better known.

L. L. B.

EARTHQUAKE IN FINLAND, 1898.

Jordskalfvet den 5 Nov., 1898. *By* K. A. Moberg. *Fennia*, 1901, *vol. xviii.*, *No.* 6, *pages* 1-28, *with a map.*

The author collects in this paper all the observations recorded in respect of the earthquake which took place in northern Finland and part of Sweden, a few minutes before 1 o'clock on the morning of November 5th, 1898. The area over which it extended is shown by the isoseismic curves plotted out on the map that accompanies the paper.

Although at some localities two distinct shocks are said to have been felt, the records do not agree as to the interval between these shocks; and the greater number of reports concur in describing the earthquake as consisting only of one shock. It appears to have travelled from south-east to north-west, and caused no damage of any consequence. The sound, described as resembling the clattering of heavy cart-wheels on a hard frozen road, was much louder within the epicentral area than outside it. Moreover, the sound preceded the actual shock within the epicentral area, but outside that area sound and shock were simultaneous.

On the author's map are also plotted, for purposes of comparison, the isoseismic curves of the earthquakes which took place, they too around the Gulf of Bothnia, on June 15th and June 23rd, 1882. These isoseismic curves show that the epicentral area of the recent earthquake lies east-north-east of the similar areas of the preceding earthquakes. L. L. B.

THE SWEDISH EARTHQUAKE OF NOVEMBER, 1901.

Meddelanden om Jordstötar i Sverige. By E. SVEDMARK. *Geologiska Föreningens i Stockholm Förhandlingar,* **1902**, *vol. xxiv., pages* **85-120**, *and* **1** *map.*

Vermland is reckoned among those provinces of Sweden wherein earthquakes are of fairly frequent occurrence, and it formed the epicentral area of the earthquake which took place in the night of November 9th to November 10th, 1901. About one second before midnight, two immediately consecutive shocks were felt at Karlstad (the customary centre of the Vermland earthquakes), followed by a rumbling like thunder and by a series of after-shocks. The seismic waves travelled on the whole from north-west to south-east, and the latest and feeblest shock was observed about 2·30 a.m.

Having sent out circulars with the usual schedule of questions, the author received replies from 54 localities, and with the help of these he was enabled to plot out the isoseismic curves on the map which accompanies his paper. As above mentioned, Vermland forms the epicentral area, but the outer isoseismic curve extends from Christiania on the east to Upsala and Södertelge on the west, that is, almost as far as Stockholm.

The earthquake-sound, by some observers, is said to have culminated in something like a resounding thunderclap or the noise of a shot fired by dynamite. Allusion is also made to a glare or flash of light, which might possibly be due either to an electric discharge or to fluorescence. One does not gather that any damage to persons or property was suffered.

In Sweden, these seismic phenomena are in no wise associated with vulcanicity, rather may they be regarded as due to purely tectonic causes, such as sagging or settling along a line of fault, etc. L. L. B.

EARTH-TREMORS, ETC., AT ZI-KA-WEI, CHINA.

Phénomènes observés à Zi-Ka-Wei (Chine) lors de l'Éruption de la Martinique. By — DE MOIDREY. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences,* **1902**, *vol. cxxxv., page* **322**.

The observatory at the above locality in China is situated not more than 10 minutes of a degree distant from the meridian which corresponds in the Old World to the meridian of Martinique in the New World. Now, on the day and at the time of the eruption of the Montagne Pelée,the bifilar pendulum registered a sudden increase in the horizontal component (after a long period of magnetic calm), and for 8 hours thereafter the instrument was agitated by what must have been a mechanical cause. The mercury-column, too, of the great barometer quadrupled in thickness, acting as a sort of seismograph: this thickening was followed by a second sudden increase of the horizontal component, and that, after an interval of 3 hours or so, by a third. A quiet period of about 7 hours supervened, then a fresh disturbance took place, lasting far into the next day.

Thus in China, just as at Paris and at Lyons, a period of magnetic disturbance began at a time coincident with the Martinique eruption; and there were also earth-tremors, which appear to have taken about 4½ hours to travel from the West Indies to the far east of Asia. L. L. B.

THE PROPAGATION OF EARTHQUAKES.

Propagazione dei Terremoti. *By* Giulio Grablovitz. *Atti della Reale Accademia dei Lincei*, 1902, *series* 5, *Rendiconti*, *vol. xi.*, *pages* 177-185.

From the complex of records obtained by modern methods of the seismographic registration three principal phases emerge:—

1. Rapid undulations which, coming, say, from Japan, reach Italy about ¼ hour after the commencement of the earthquake at the epicentrum, and are protracted for several minutes.

2. Slackened undulations, of greater amplitude than the foregoing, arriving 10 minutes later, or 25 minutes after the commencement at the epicentrum.

3. Slow oscillations of 15 seconds period, 30 minutes after the first phase, or 45 minutes after the commencement at the epicentrum. These oscillations generally attain their greatest amplitude 5 or 10 minutes after their first arrival, and they are preceded by extremely slow oscillations (of 60 seconds period), of inconsiderable amplitude and revealed alone by specially delicate instruments. This third phase occasionally lasts for a few hours, and the instruments available are hardly sensitive enough to determine the precise moment at which it ceases.

The author points out that the hypothesis of longitudinal and transverse oscillations, lately received with much favour, takes into account the first and the third phases, but leaves unsolved the problems attaching to the second phase. The intervals between the three phases and their duration increase concurrently with the distance from the epicentrum; and the author explains on what grounds he established his formerly suggested co-efficient of 186 miles (300 kilometres) for every minute's interval between the beginning of the first and that of the third phase. He now shows to what modifications this co-efficient is subject, in view of improved methods of seismographic registration, discussing for this purpose the results obtained by Messrs. Milne, Oldham and Belar. The varying velocity of the first phase causes the co-efficient to vary according to the distances, but the tabulated results show that the range of variation is, after all, not so very great, and the rough estimate of 300 was nearer the truth than might have been expected.

In the analysis of earthquakes over an area where the general public has been conscious of their occurrence, the distances dealt with rarely exceed 620 miles (1,000 kilometres). Moreover, at most points of observation, it is not the actual first oscillation that is recorded, but a more advanced phase, and even in recording this there is some delay. Then, although it is usual in dealing with remote earthquakes to regard the co-efficients of velocity as constant, we should bear in mind the modifications which they may undergo over short distances, in consequence of the predominance of strata more or less favourable to rapid seismic propagation. The third phase itself, of the ascertained velocity of 2 miles (3 kilometres) per second in the epicentral area, is more distinctly felt, and actually "overhauls" the others. The depth of the epicentrum, largely negligible over great distances, is a factor of considerable importance over short distances. The author concludes, therefore, that very precise observations, made with the very best instruments, are necessary, in order to deduce those laws which one may vainly attempt to build on incomplete and inexact narrations.

L. L. B.

FOLDING OF ROCKS IN RELATION TO EARTHQUAKES.

Sur l'Influence Sismique des Plissements armoricains dans le Nord-ouest de la France et dans le Sud de l'Angleterre. By F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences,* 1902, *vol. cxxxiv., pages* 786-788.

The author, a well-known seismologist, states that the object of this paper is to show in what measure the instability of the earth's crust is traceable to those post-Carboniferous, so-called Armorican, folds, which characterize the region now occupied by the south-west of Ireland, the northern shores of the Bristol Channel, Cornwall, and the French Palæozoic massif (Britanny, the Cotentin, and Vendée). Seismic epicentra are disseminated all over this area, but attention is directed to the manner in which those that are most frequently the *locus* of earthquakes are grouped together. Isolated and infrequently active epicentra may be generally traced, with a considerable show of reason, to some local geological "accident" or fault-line.

Epicentres may be traced along the Armorican folds in county Cork, and across into south-western Pembrokeshire (Haverfordwest, etc.), and thence right into the Mendips. The great fold disappears at Frome beneath the Mesozoic formations, but it is evidently continuous at some depth below the South Downs, reappearing in France, where its course is marked by seismic epicentra through the Boulonnais and into Belgium. In the same way a connection is traced between the Armorican folds and the seismic epicentra, from Dartmoor to the Scilly Isles and across to Britanny and in the Channel Islands. Metalliferous injections appear to have had no seismic influence in Cornwall, but the same assertion cannot be made in regard to the elvans. Nor do granitic intrusions, whether in Cornwall, or in south-western Ireland or in Vendée or Britanny, coincide with any important seismic epicentra.

The geological phenomena which resulted in the breaching of the formerly continuous land-line by the Irish Sea and the English Channel had no influence in determining the seismic instability of the area, any more than the late Tertiary elevations and subsidences. Similar observations hold good concerning many regions of the globe's surface, for such phenomena as these are too superficial, while the origin of the great folds may be very deep-lying.

"To sum up—the Armorican folds, despite their great antiquity, have retained a remnant of vitality, in the shape of fairly frequent, not very intense earth-tremors, with numerous epicentra." The older "Caledonian" folds, with which the Armorican folds are associated along the northern shore of the Bristol Channel, constitute, on the other hand, an element of stability.

L. L. B.

THE FOLD-THEORY OF EARTHQUAKES.

Les Tremblements de Terre de Plissement dans l'Erzgebirge. By F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences,* 1902, *vol. cxxxiv., pages* 96-98.

In the region, which is bounded by the Frankenwald on the west, the Eger on the south, and the Elbsandstein on the east, earthquakes without being, as a rule, of disastrous intensity, are of frequent occurrence. Geologists are generally agreed that the physiographical structure of the region is in great part the outcome of a triple folding, begun in Archæan times and continued during subsequent periods; this folding took place from south-east to

north-west, and thus arose three sensibly parallel ranges trending from south-west to north-east:—The Mittelgebirge being the southernmost, the Erzgebirge lying north of it, and the Liebschütz Hills north of that again. The Erzgebirge, the most elevated and longest fold of the three, slopes on the one hand down to the peneplain of Saxony, and on the other abuts as a great wall on the Eger Valley and the Bohemian volcanic fault. This fault-line is marked by many thermal springs, among which those of Franzensbad and Teplitz are the most renowned. The whole area has been injected with granitic and other laccolites, and complicated with basaltic flows. Metalliferous veins of various composition and age course in every direction through the rocks. In the troughs of the folds lie the more or less eroded sedimentary deposits.

The instability of the region is manifested by the number of epicentres. 150 or more, scattered all over it, but perhaps more closely clustereed together in the south-west of the Erzgebirge than elsewhere, and Graslitz and Brambach may be regarded as the districts of greatest seismicity. Now, the Graslitz-Brambach epicentres are evidently connected with certain huge quartz-reefs which fill up long fractures running at right-angles to the Erzgebirge range. and in some cases crossing even the Eger valley. Owing to this and other circumstances, the author infers that the folding movement begun in the dim recesses of Archæan time is still going on, and the recent earthquakes are its attenuated manifestations.

On the other hand, the innumerable fractures that characterize the Vogtland and Saxony have, on the whole, given rise to only a small number of epicentres. It is as if the quartz-infilling had cemented that area into a gigantic breccia, and thereby made it more stable than otherwise. Here then faulting has an exactly opposite effect, so far as seismicity is concerned, to folding a conclusion which is confirmed on examining the circumstances connected with the great Bohemian volcanic fault.

Saxon Switzerland, despite its rugged configuration, is a very stable area. A few unimportant epicentres along the right bank of the Elbe. are connected with the great dislocation of the Lausitzerwald granite.

The author points out, however, that it would be very rash to connect every seismic epicentre with some neighbouring geological dislocation or such like phenomenon. Still less is it advisable, as many seismologists have done, in the absence of visible geological disturbances, to regard earthquakes as the outward manifestation of unknown subterranean faults.

To sum up, in the Erzgebirge, out of three kinds of geological phenomena implying at least temporary instability (fracture-areas, volcanic "lines of least resistance," and folds) the last-named alone has remained a living force down to our own days, manifesting itself by means of earthquakes.

L. L. B.

THE RELATIONSHIP OF SOUND-PHENOMENA TO EARTHQUAKES.

Über die Beziehungen zwischen Erdbeben und Detonationen; and *Bericht über das Detonationsphänomen im Duppauer Gebirge am* 14. *August*, 1899. *By* J. Knett. *Sitzungsberichte der Mathematisch-naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften* [*Vienna*], 1900, *vol. cix.*, *abtheilung I.*, *pages* 700-734, *with* 3 *figures in the text*, *and pages* 735-767, *with* 6 *figures in the text and* 2 *plates.*

Pointing out in the first place the general consensus of experience that the sound which accompanies an earthquake is directly proportional in in-

tensity to the violence of the shock, the author draws attention to certain cases wherein the terrific loudness of the sound-phenomena has, however, been out of all proportion to the comparatively feeble vibration of the soil. To seek for the cause of these it seems needful to start from the premiss that certain "earthquake-sounds" or detonations are independent phenomena, the result of one or more causes originating in a particular focus, and the earth-tremors observed in connexion with them are merely accessory accompaniments originating in the same focus.

Feeble detonations are unaccompanied by any observable earth-tremors. Among such the author reckons the "Barrisal guns" of Java, the Gangetic plain, and the Congo, the "Marina" of the Umbrian coast, and the "Mistpœffers" or "Zeepœffers" of the Flemish coast. These phenomena, feeble though they be, are remarkable for their continual recurrence at the same localities, and it may be remembered that Prof. George Darwin has assigned them to microseismic movements of the earth's crust.

Of another order are the "detonation-swarms," consisting of a more or less rapid succession of thunderous sounds, in a region where they have not occurred before and do not recur so far as we know. Such "swarms" may go on for weeks, months, or even years at a time. Such were those of Guanaxuato (Mexico) lasting from January 9th to February 14th, 1784; of Villaga, Italy, from November 4th to December 26th, 1851; of Meleda, Dalmatia, lasting from 1822 to 1825. After a short description of these, the author proceeds to discuss minutely the relation between tremor and detonation, and seeks to prove that in a given medium both travel with an equal velocity—in a word, that the seismic and acoustic waves transmitted by ponderable matter have much the same mutual relationship as the electromagnetic and optical waves transmitted by imponderable matter. This equality of velocities in the purely seismic phenomena of the lithosphere applies only to the rapid [transverse] vibration-waves. What the author terms "not purely seismic, or mixed" phenomena of the lithosphere, such as tremors connected with certain volcanic eruptions, give rise to acoustic waves which, however, are propagated with the slow [longitudinal] earth-waves. He enunciates his "detonation-theory" as follows:—Earth-sounds are for the most part mixed phenomena of predominantly acoustic origin. These are propagated from their focus through the earth's crust by means of waves which correspond to the earthquake-waves proper (slow waves), and possess the same velocity as the last-named. The "report" of such detonations bears no analogy to the noises heard before the principal shock in most earthquakes. The detonations are of various intensities, and are, as a rule, accompanied by vibrations of the surface of the environing medium, the intensity of such vibrations being generally concordant with that of the "report."

Detonations are classified by the author, according to their degree of intensity, in five categories, and he emphasizes by description and diagram the distinction between these phenomena and earth-tremors. He then endeavours to trace out the possible causes of the phenomena, and refers in this connexion to sudden outbursts of gas below ground and to the sudden caving-in of subterranean caverns, etc.

In his second memoir, he describes the detonation-phenomena observed around Duppau in Bohemia on August 14th, 1899, between 6 and 6.15 p.m. These consisted of a couple of subterranean "thunderclaps" of medium intensity (3 in the author's scale), accompanied by a feeble earth-tremor (2 to

3 in the accepted scale). The sky was cloudless, and the first "clap" was especially startling. The localities where the sounds were observed fall within a circle, the diameter of which does not exceed 8¼ miles. After a very detailed discussion of the facts, including considerations on the form of undulations and the possibility of "total reflection" within the earth's crust, the author points out that the volcanic massif of Duppau, which is cut in two by the great Bohemian fault, arose along two main dislocations with which are connected a number of smaller faults. The district is no stranger to the seismic phenomena, but the author appears inclined to attribute the "detonations" to an outburst of gas taking place among the rocks at some depth below the surface. L. L. B.

THE CAUSES OF EARTH-TREMORS.

Bradisismi e Terremoti della Regione Benacense. *By* G. B. Cacciamali. *Bollettino della Società Geologica Italiana*, 1902, *vol. xxi., pages* 181-196.

A study of recent earthquake-phenomena in Northern Italy, as well as of the Tertiary and prehistoric seismology of the same region, has led the author to the following conclusions, among others:—

1.—The slow oscillations of the soil (or bradyseisms) affect considerable areas of the earth's surface; whereas the rapid oscillations (or earthquakes) are comparatively localized, although the undulations may be propagated over regions of far greater extent (eccentric earthquakes) than those subject to bradyseismic influence.

2. The crumplings and contortions of the strata, the lines of faulting, dislocation, and fracture, amid rocks of the same age, prove that bradyseismic phenomena have taken place in all geological periods. The limiting-lines of the bradyseisms may be parallel or sub-parallel, continuous or interrupted, straight or sinuous.

3. The principal seismic areas are grouped in relation to these lines, and therefore most earthquakes are connected with the tectonic irregularities of the area in which they occur. So then, most earthquakes are intimately connected (by derivation) with bradyseismic phenomena.

4. The settling-down of the rock-masses which form the earth's crust, is the cause both of bradyseisms and earthquakes. But the latter, just as are volcanoes, are subordinate to the former, which constitute the chief factor in orogenic development. It is sheer obstinacy of scientific tradition to attribute earthquakes to any other cause that can be raked up except this slow sagging (such as tension, liberation, or subterranean explosion of gases, movements of molten magmas, etc.). So too, by inveterate habit, in referring to orogenic development or mountain-building we speak of uplifts of the soil, whereas the secular sagging resolves itself mostly into subsidences.

5. The mode of juxtaposition and junction of rock-masses consequent on the final or quasi-final settling-down of a given area, is a factor which tells against ulterior movements among these masses. So the bradyseismic areas tend more and more to become localized, until they become identical with tachyseismic (earthquake) areas, and these tend finally to disappear.

The author states that he does not pretend to have said the last word on the subject, but rather to have shown the way whereby we may finally attain to a rational and correct explanation of telluric phenomena. L. L. B.

THE DIURNAL OSCILLATIONS OF THE SOIL.

Die tägliche periodische Schwankung des Erdbodens nach den Aufzeichnungen eines dreifachen Horizontalpendels zu Triest. By EDUARD MAZELLE. *Sitzungsberichte der Mathematisch-naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften* [*Vienna*], 1900, *vol. cix., abtheilung I., pages* 527-651 *and* 5 *plates*.

This very exhaustive memoir, amply illustrated by plans, diagrams of curves, tables of results, etc., gives an account of the observations systematically conducted at the Imperial Observatory in Trieste, by means of the Rebeur-Ehlert horizontal pendulum, as to the periodic oscillations of the soil. The hill on which the observatory is built consists of Flysch (older Tertiary) marls and sandstones, which abut on the north-east upon the limestone-plateau of the Triester Karst. The pendulum is borne by a pillar of limestone erected on a sandstone-and-cement base (independent of the floor of the Observatory), which at a depth of 4½ feet rests on the live rock (sandstone). The room in which the instrument is set up is practically underground, and during a period of sixteen months the average variation of temperature from one day to the next was only 0·23° Fahr., and the diurnal variation averaged 0·55° Fahr. This is about $\frac{1}{15}$th of the amplitude of temperature-variations observed at the same time in the outside atmosphere.

The general conclusions at which the author has arrived may be summarized as follows:—

The observed oscillation of the pendulum-pillar during the course of a day is expressed by an ellipse, the great axis of which is directed east 20° north and west 20° south. The most considerable deviation to the east-north-east occurs after 4 a.m., and that towards the west-south-west after 1 p.m. The influence of the meteorological elements on the periodic oscillation is betrayed by the observation that the oscillation is most regular in August (the month which at Trieste shows the greatest percentage of sunshine, the fewest clouds, and the least rainfall), and most complicated in January (the month of least sunshine and greatest rainfall).

The memoir contains many other interesting results and considerations which cannot be dealt with in an abstract. It may be pointed out, however, that the observations bore on semi-diurnal as well as on diurnal oscillations.

L. L. B.

THE SEISMOLOGICAL OBSERVATORY AT BUDAPEST, HUNGARY.

Mitteilung über die erste Einrichtung der Erdbebenwarte in Budapest. By DR. FRANZ SCHAFARZIK. *Földtani Közlöny*, 1902, *vol. xxxii., pages* 268-269.

Regular work was begun at this establishment on March 1st, 1901, and records of observations are published every two months. The *locus in quo* consists of a basement, 135 feet away from the street and 16½ feet below road-level, in the new building of the Royal Hungarian Geological Institute. This is situated in a quiet suburban district.

As seismographs, two horizontal Grablovitz-Omori pendulums, made by Mr. Bosch of Strasburg, are used. One is placed in a north-and-south direction, and the other at right angles to it. The whole installation is mounted on isolated stone-pillars, sunk in the earth about as far down as the water-level of the sandy drift-deposits. The normal temperature of the basement is 58° Fahr.

With this apparatus, only shocks of some importance can be registered.

Earth-tremors, such as those caused by the railway-trains which rattle past half a mile or so away, or by batteries of artillery going along the road, are not recorded by it. The records are traced automatically on blackened paper.

Disturbances registered on April 19th, 1902, were doubtless associated with the Guatemala earthquakes; and those recorded on July 5th and August 22nd in the same year were similarly connected with seismic phenomena of which the centre lay at Salonika in the first instance, and Kashgar in the second. L. L. B.

UNDERGROUND SEISMOLOGICAL OBSERVATORY AT PRZIBRAM, BOHEMIA.

Die unterirdische Erdbebenwarte in Przibram. Anon. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1903, *No.* 7, *page* 238.

The Vienna Academy of Sciences has defrayed the cost of setting up Wiechert pendulum-seismographs above- and below-ground at Przibram. Above-ground, the instruments are lodged in a small stone-building, in which besides the seismograph are various electric batteries, a clock, and a telegraph-apparatus, to which the exact time will be signalled from the Vienna astronomical observatory. Below-ground, the seismograph is set up in a walled chamber in the Przibram mine, at the depth of 3,657 feet: an electric cable 8,528 feet long joins up the underground seismograph with that above-ground. Each of these two instruments weighs 2,645 pounds.

Among the unfavourable conditions attending the installation may be mentioned the continuous vibration due to the ore-picking machinery. There are also unavoidable variations of temperature which cause the pointers to oscillate slowly, but continually. Ingenious corrections have been applied to eliminate these disturbing factors, and apparently with success. A distant earthquake of some importance was recorded recently by both instruments, and the records from above- and below-ground agreed in practically every particular. L. L. B.

SEISMOLOGICAL OBSERVATORIES IN THE GERMAN EMPIRE.

Ueber Vertheilung, Einrichtung, und Verbindung der Erdbebenstationen im Deutschen Reich. By G. Gerland. *Petermanns Mittheilungen*, 1902, *vol. xlviii., pages* 151-160, *with a map in the text.*

The movement for establishing on the Continent of Europe a network of observatories where earthquake-phenomena will be duly recorded, and the results of scientific work properly co-ordinated, is proceeding apace. Much is due to the intelligent interest which the various governments concerned manifest in the matter, as well as to the perseverance and enthusiasm of such experts as the present author. His paper embodies the plans which he is drawing up for the distribution of seismological observatories within German territory. The central station is at Strasburg in Alsace, and he proposes eleven other main stations at Aix-la-Chapelle, Karlsruhe, Darmstadt, Munich, Göttingen, Hamburg, Leipzig, Jena, Breslau, Königsberg, and Potsdam. These localities are not selected haphazard, but after careful consideration of the tectonic structure of the country, that is, the main lines of faulting and folding of the rocks. In addition, twenty-five stations of secondary importance are suggested, and the author asserts that the

number proposed will be sufficient, but not more than sufficient, to carry on properly a seismological service. The most important duty that will fall to the secondary stations is the collection of replies to printed formularies regarding time, duration, effects, etc., of earth-tremors. These replies, when collected, will be despatched to the nearest main station, to which also monthly reports will be sent concerning the observations made with the simple apparatus in use at the secondary stations (automatically-recording pendulum, etc.).

The chief task incumbent on the main stations will be the recording of microseismic movements and of distant earthquakes. The apparatus there will consequently be of a more complicated and costly description than that provided for the secondary stations. For instance, the Rebeur horizontal pendulum and the Wiechert astatic pendulum will be set up in them. Monthly and yearly reports will be issued from each main station regarding its own district; and here it may be observed that the delimitation of seismological districts according to political boundaries will but seldom fit in with a delimitation based on scientific grounds.

The Imperial Central Station at Strasburg will furnish a conspectus of the microseismic phenomena recorded throughout Germany, and the area of propagation of every important earthquake will be mapped as accurately as possible, the whole of the information being published yearly somewhere about the month of April. The apparatus from the subordinate stations will be continually tested at the central station, new instruments experimented with, and so forth. The entire organization is under the superintendence of a committee, on which sit two representatives of the Government.

Finally, it is proposed to establish underground observatories in the mines at Freiberg, Zabrze, and Klausthal, to supplement the records obtained from the observatories above-ground.

The author lays due stress on the enormous practical importance of the organized study of seismological phenomena; for the miner, the architect, the builder, and the manufacturer, may all find themselves called upon at any moment to deal with problems dependent on such phenomena.

L. L. B.

A SEISMOGRAPH FOR VIOLENT EARTHQUAKES.

Sopra un Sismografo per Forti Terremoti. By G. Agamennone. *Atti della Reale Accademia dei Lincei, series* 5, *Rendiconti,* 1902, *vol. xi., pages* 116-122, *with a diagram in the text.*

This new instrument, called by the author, the macroseismometrograph (in contradistinction to the microseismometrograph) has been devised to record earthquakes which are of such intensity as to render useless the habitual, more sensitive, recording-instruments. Its necessity was proved by the Latian earthquakes in recent years, when all the instruments in the Rocca di Papa Observatory and at the Seismic Experimental Station in Rome were thrown out of gear. The new macroseismometrograph was set up in the Royal Geodynamical Observatory of Rocca di Papa, in September, 1901.

Premising that for the proper study of earthquakes the vibrations of the soil should be resolved into three components at right angles one to the other (that is, two horizontal and one vertical), the author describes the construction of the two small horizontal pendulums which he uses for

registering the first two components. Their method of suspension is very similar to that adopted in Ewing's bracket-seismometer, and is so contrived that the most powerful shocks directed against the base of the instrument will not sensibly affect the due working thereof. The period of a simple oscillation is 4 seconds, exactly as if we were dealing with a vertical pendulum, 52 feet long. For the registration of the vertical component, the author uses a heavier mass of lead (4·4 pounds) than the cylinders constituting the bobs of the horizontal pendulums (3·3 pounds), the suspension from four steel-supports being also on the Ewing system. The entire apparatus has been arranged with a view to great economy of space, and the records are automatically traced by the three styles connected with the respective pendulums, on a smoked and lacquered paper-roll, about 10 inches broad and 11½ feet long. The author describes the simple mechanism whereby rapid and also accurate rotation of the roll is secured. Moreover, on the same roll, a fourth style, electrically set in motion by a chronometer, marks off the seconds and minutes of time.

No sufficiently violent earthquake, he remarks, has occurred since September, 1901, at Rocca di Papa, to enable him to state that the macroseismometrograph has fulfilled all his expectations. It is true that the new instrument was set in motion on October 15th of that year, when a shock of considerable intensity occurred in the Abruzzi, and on December 16th, when an earthquake of moderate intensity took place in Umbria: but, as might have been expected, the styles on each occasion traced out perfectly straight "curves" (if the anomalous expression be permissible). This sufficed to show, however, that the whole mechanism works well. Before setting up the instrument at Rocca di Papa, the author had experimented on it with as good an imitation as he could devise of seismic vibrations, and was sanguine from the results thus obtained that it will prove to be of great practical value. He figures the artificial seismogram obtained in the course of these preliminary experiments, and takes occasion to point out the necessity for great speed of revolution of the recording-roll.

L. L. B.

COAL-OUTCROPS.

Coal-outcrops. By CHARLES CATLETT. *Transactions of the American Institute of Mining Engineers,* **1900**, *vol. xxx., pages* **559** *to* **566** *and* **1105** *to* **1109**.

The writer draws attention to the extent to which a bed is affected by its outcrop at the surface; and having examined a number of openings immediately at the surface, and also a short distance under cover, he gives a number of actual sections bearing on the subject.

Whatever may have been the original variations, it may be assumed that coal-basins presented in comparatively modern times approximately parallel beds interstratified with fire-clay, slate, sandstone, etc. It is obvious that, along the lines of actual outcrop, the beds exist under different conditions from those ruling at some distance under cover in their exposure to atmospheric agencies, pressure and erosion. The effect of the first is to decompose and soften many of the strata; of the second, when exerted unequally, to cause the movement of such material as was at all plastic towards the point of least pressure; and of the third, to remove the strata wholly or in part. The pressure is not as great at or near the outcrop as it is some distance under cover, and the tendency would be

to increase the thickness at the former point. This is usually not conspicuous, since the material thus forced to the surface is peculiarly subject to erosion and removal, so that the effect on the level of the various strata is small, and is often offset by local conditions. Yet it exists; and in places where the beds of coal are underlain by thick beds of plastic fire-clay, they commonly show a dip from the outcrop, owing to the thickening of the fire-clay bed at that point. Of the sections given, the thickness of coal shows under cover an average increase of 6 per cent. in 6 sections, and a decrease of nearly 5 per cent. in 7; while the thickness of partings increases 27 per cent. in 5 sections, and decreases 30 per cent. in 6.

An examination of the sections will disclose a marked similarity between the seam at the surface and when opened a reasonable distance under a solid top. The changes due solely to the nearness of the surface can be recognized and allowed for, so that it is possible to form from the outcrop a very nearly accurate idea of what may be expected 50 or 60 or 75 feet under the top. A very soft, sooty material, called "mother-coal," may pass, in that distance, into a coherent but friable material, usually exceedingly pure. Hard streaks in the coal are emphasized at the surface; and a material which is coal, but is obviously high in ash, may be found, owing to the increase of oily and volatile material, to become of fair quality and be classed as pure coal. A slaty material, which is very black and friable, will, as a rule, pass into inferior coal, and, when in small quantities, would probably be described as bony coal at 50 feet from the outcrop. Hard, undecomposed grey slate, on a well-defined bed, may be expected to continue as such without alteration. A plastic slate or fire-clay, existing as part of the coal-bed, may usually be expected to thin very considerably within a short distance, as its section is generally increased by the reduction of pressure at the outcrop. A. W. G.

THE THEORY OF EROSION IN RELATION TO METALLIFEROUS DEPOSITS.

Sur la Notion de Profondeur appliquée aux Gisements Métallifères Africains. By L. De Launay. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 1531-1533.

The author had previously expressed the opinion that the characteristic type of metalliferous deposits in a given region might depend on the depth reached by erosive agencies in that region; or, in other words, on the depth at which that portion of the deposits now being mined lay, when those deposits were formed. The depth to which erosion, reducing an area more or less to the form of a plateau, has gone, bears some relation to the epoch at which the latest folding of the area took place.

In order to test this hypothesis, it is necessary to enter on the comparative study of countries which have undergone folding at different epochs, with the view of showing that their metalliferous deposits fulfil the postulated conditions. The author commenced with the African continent, the southern portion of which was last folded in Carboniferous times, while the north-eastern portion underwent folding as late as Tertiary times. These two regions, in regard to their metalliferous deposits, show precisely the antithesis required by the author's theory.

The metalliferous deposits of Algeria and Tunisia are manifestly connected with the littoral volcanic belt, and consist of complex sulphide veins

containing variable proportions of iron, copper, lead, zinc, antimony, and mercury. These veins are very much scattered, crushed, and dislocated amid a chain of (geologically) very recent folds. Copper and iron are predominant near the coastal eruptive belt, while zinc and lead predominate farther away from it. Erosion has not gone on long enough to plane down the irregularities of the surface, and so the general water-level of the country lies often at a great depth; there is consequently very active circulation of underground waters, and oxidic metamorphism of the various metallic sulphides is widespread and deep-reaching.

All other known ore-deposits on the African continent differ entirely from those just described as characteristic of its north-eastern portion. The "filonian" or vein-type, properly so called, is conspicuous by its absence, and the metalliferous deposits are in the form of lenticles, pockets, "bedded-veins," or impregnations. Besides hæmatite, magnetite, iron-pyrites, we have here copper and nickel-ores, and the characteristic occurrence of gold. Erosion having cut down to the old crystalline rocks, the ores associated with these become accessible, such as tin and bismuth in the granites, chrome-iron-ore and nickel in the peridotites and norites. Mercury is absent, zinc and lead-ores are comparatively scarce. The superficial oxidation of the ores extends very little downward. In a word, nothing in the Sudan, the Congo Basin, Katanga, the German protectorates, Rhodesia, or the Transvaal, but what shows diametrically opposite characteristics to the deposits of the newer portion of the continent (Algeria, Tunisia, etc.).

L. L. B.

THE ORIGIN OF KAOLIN-DEPOSITS.

Beiträge zur Kenntniss einiger Kaolinlagerstätten By H. RÖSLER. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1902, *Beilage-Band XV.*, *pages* 231-393, *and* 3 *text-figures.*

This painstaking memoir gives, in the first place, a most elaborate bibliography of the subject, comprising no less than 303 entries. Then follows an introductory chapter dealing mainly with the chemical composition and physical properties of kaolin, and the author lays stress on the fact that wherever the mineral occurs it is undoubtedly a decomposition-product. He tabulates synoptically the changes in chemical constituents whereby the felspars (orthoclase, albite and anorthite respectively) are transformed into kaolinite. Some writers believe that the kaolin of Passau in Bavaria is derived from the decomposition of scapolite, but the author shows that scapolite cannot by any possibility give rise to kaolin.

The minerals more or less frequently associated with kaolin are dealt with in detail, and the author then proceeds to describe a great number of deposits from Bornholm in the north to Limousin in the south, and from Bohemia in the east to Cornwall in the west. Those of Cornwall and the Bourbonnais are, it is well known, intimately associated with the occurrence of tin-ore; while in Colorado kaolin-deposits are associated with galena, pyrites, and silver-ores, and in New Mexico with turquoise-bearing veins. In the neighbourhood of Passau in Bavaria, of Schwarzbach and Krumau in Bohemia, and also in Ceylon, kaolin is associated with graphite-deposits. There are, of course, numerous examples of kaolinized granites unassociated with any other mineral-occurrence of industrial interest; as, for instance the kaolin-deposits around Karlsbad (described at great length), those of

Oberlohma near Franzensbad, those of Tirschenreuth and Wiesau in the Upper Palatinate, etc.

The author deals separately with kaolinized aplitic veins and apophyses in crystalline schists. He sees in these undoubted evidence that kaolinization took place through post-volcanic changes within the aplite-intrusions themselves. The most extensive occurrences of this type are the deposits of Limousin in Central France. On the other hand, the most important German deposits of kaolin occur among the quartz-porphyries and associated rocks of Saxony, along an east-and-west line defined by the towns of Meissen, Mügeln, and Halle. These occurrences are described in some detail.

Some attention is then given to the secondary kaolin-deposits (or placers as we might call them) containing kaolin drifted by water-transport from its original *locus*, and forming kaolin-sandstones, kaolin-clays, and refractory clays.

The author points out that weathering is not the cause of kaolinization: the two processes are fundamentally distinct, and their terminal products cannot be confounded one with the other. Kaolinization is started in quite a different way from weathering, one proof among others being that semi-kaolinized rocks, when exposed to weathering agencies, do not become further kaolinized, but simply crumble away to fragments.

He considers that the agents of kaolinization came from below, in the form of vapours and hot solutions, chief among them being fluoric, boric, and sulphuric acids. These exhalations and thermal waters probably acted with far greater intensity than any of those now active, and no doubt date back to an epoch of great vulcanicity,—perhaps to the times immediately following on the eruption of the granites and quartz-porphyries.

L. L. B.

THEORY OF FORMATION OF PETROLEUM.

Synthèse de divers Pétroles: Contribution à la Théorie de Formation des Pétroles naturels. By P. SABATIER *and* J. B. SENDERENS. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv.*, *pages* 1185-1188.

By acting on acetylene with hydrogen gas in presence of a column of finely-divided nickel maintained at a temperature of 200° Cent., the authors obtained in a cooled tube, a liquid possessing much the same chemical composition, physical characters, and specific gravity as American petroleum. By directing upon a similar column of nickel at a similar temperature a rapid current of acetylene, the authors ultimately obtained a greenish liquid possessing the characteristics of Caucasian petroleum. They describe the distillates obtained by fractionation, and they point out that intermediary oils (between the American and the Caucasian) are produced, if the acetylene before reaching incandescence is mixed with a given proportion of hydrogen. If hydrogenation, subject to incandescence, is carried on at a temperature higher than 300° Cent. oils possessing the characteristics of Galician petroleum are obtained.

From these synthetic experiments the authors deduce their theory of the formation of petroleum in nature. They suppose that in the depths of the earth are variously distributed in the free state alkaline and earthy-alkaline metals, as well as the carbides of the same. Water coming into contact with the metals sets free hydrogen, and when it comes into contact

with the carbides acetylene is given off. These two gases, in varying proportions meet in the finely-divided state metals which are in nature of very widespread occurrence, such as nickel, cobalt, and iron. Thus the conditions of the authors' synthetic experiments are fulfilled, the reactions which they have reproduced take place, and the different varieties of petroleum are formed. Messrs. Berthelot and Mendelejev had already hinted at this theory, which is by no means intended to be of universal application. Thus Dr. Moissan's idea that some petroleum is formed direct by the action of water on metallic carbides still holds good; and, so too, much petroleum is of animal or vegetable origin.

But none of the theories hitherto proposed had fully accounted for the diversity of natural oils. The authors claim that this is now satisfactorily accomplished, their syntheses being especially helpful in throwing light on the genesis of Caucasian petroleum. L. L. B.

THE ORIGIN OF PETROLEUM.

The Origin of Petroleum. By JULIUS OHLY, Ph.D. *Mines and Minerals*, 1902, *vol. xxii., pages* 532-533.

The theory that petroleum has been derived from the decomposition of vegetable matter has been widely, if not generally accepted, but the author rejects it for very cogent reasons. Petroleum has been found in strata where the vegetable matter could not have been forthcoming in sufficient quantity, whilst by referring it to the Carboniferous age, we get the necessary organic débris, but fail to find that the necessary heat was to be had. The author falls back on the theory that the oil has been produced from carbonaceous metallic compounds, and thinks that this view will be generally adopted in the future.

Explaining this theory, he remarks that elements of lower atomic weights, such as carbon, calcium, iron, etc., predominate in nature. Carbon and iron especially are amongst the most widely diffused elements, they are most difficultly fusible, and hence most easily condensed. They must have been the first bodies to liquefy during the incandescent stage of the earth's development. While the terrestrial temperature was yet a temperature of dissociation for most bodies, the liquid iron and carbon, by reason of their affinity and the high degree of heat, presumably combined with each other at that remote geological period. As the earth cooled, these large quantities of carbonized iron in the liquid state were brought into contact with steam, and gaseous hydrocarbons were formed. These rose by crevices and fissures to the overlying strata, were condensed accordingly, and meeting the water percolating the earth, were carried by their inferior gravities to the upper strata, and, in some cases, to the surface, where by oxidation they gave rise to the formation of bituminous shale, oil-sand, asphalt, ozokerite, and similar bodies, while the uncondensable part escaped as gas. It appears plausible to assume that the same process is still progressing in the earth's interior, or otherwise the inexhaustible productivity of the oil-basins becomes inexplicable.

The crude petroleum thus produced consists of a mixture of hydrocarbons, the paraffin series prevailing as a rule, the carbon and hydrogen percentages approaching the figures 85 and 15. Of these hydrocarbons, the members of the paraffin series, from methane down to pentadecane, have been

isolated. Methane is usually met with on boring for oil, and is exhaled from the gas-wells of Pittsburg, while ethane, the second member of the series of the formula C_2H_6, constitutes the gas of the Delameter gas-well in that city. The gas escaping at Baku is of the same nature, being methane, while pentane (C_5H_{12}), the fifth member of the series, prevails in the distillation product of petroleum, known as gasoline.

When steam is conducted over heated cast-iron filings, containing carbon, a number of hydrocarbons are produced besides oxides of iron. The chemical equation for this reaction is $3\,Fe_m C_n + 4_m H_2O = mFe_3O_4 + C_{3n}H_{8m}$. In this manner then the hydrocarbon C_3H_8, or propane, the third member of the series mentioned, is produced among a number of other higher hydrocarbons. This compound is a colourless gas known to occur in crude petroleum, an observation which agrees with the researches made into the nature and composition of Pennsylvanian oils. Other carbides, as calcium, for instance, give rise to the formation of the first member of the acetylene series, C_2H_2, giving further support to the theory of mineral origin. The equation for the formation of acetylene gas is:—$CaC_2 + H_2O = C_2H_2 + CaO$; and $CaO + H_2O = Ca(OH)_2$. No objection can be made as to the probability of this decomposition-process having occurred, and most likely pursued its course in the interior folds of the earth's structure. Moreover, acetylene polymerizes at a low red heat to benzine (C_6H_6) if its vapours be conducted through red-hot tubes, so that its formation under the pressure and heat existing in ancient strata becomes quite probable. Besides, the presence of hexahydrides of benzene, toluene, xylene, and pseudo-cumene in most natural hydrocarbons has been proved. If to these observations be added the fact that naphthaline is produced, together with benzine and styrene, by passing vapours of methane through heated tubes, the complexity of the natural product issuing from the oil-wells becomes better understood.

Admitting then that the conditions prevailing in those ancient geological zones were and are favourable for the production of petroleum, and that the temperature required for its generation, and the pressure which materially facilitates its formation cannot be met with in other strata of the earth, the general acceptance of the mineral theory appears probable. Any phenomenon occurring when prospecting for petroleum, like the escape of large quantities of gas exhibiting the character of methane, can be readily explained and understood by the above principles. It becomes evident, that in the great geological changes, which have given rise to the creation and separation of petroleum, the whole series of homologous hydrocarbons has been produced, from methane up to the highest paraffins. As to naphthenes, which closely resemble the paraffins, their occurrence in American petroleum has not as yet been observed, though their presence in the Russian oils has been proved. X. Y. Z.

PETROLEUM IN THE LAST CENTURY.

Ueber Erdöl im 19 ten Jahrhundert. By Josef Muck. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Příbram*, 1902, *vol. l.*, *pages* 117-148.

In this not too lengthy paper, the author satisfactorily carries out his intention of giving within a small compass a general view of the present condition of the petroleum-industry all over the world. A brief historical

introduction is followed by a tabular synopsis of the districts and the geological formations in which petroleum is known to occur; and it may well be said that the countries where the oil does not occur are few. Diagrams and tables are given showing the increase in the world's output from 1859 to 1900, the United States and Russia so far overtopping all other producers that any attempt at comparison with these appears ludicrous. It may be noted, however, that the province of Eshigo, in Japan, supplies 80 per cent. of the amount of petroleum consumed in that empire, and that Sumatra and the neighbouring islands are coming rapidly to the fore as producers.

The origin of petroleum is discussed at some length, and the author inclines to the belief that it is mostly the result of the slow distillation of animal-remains, especially fishes—swept perhaps by currents into such supersaline gulfs as that of Karabugas, killed there *en masse*, and buried beneath sandy and clayey deposits. He points out how precisely those geological formations where petroleum is most abundant supply evidence in support of this hypothesis.

Petroleum-refuse, *massut* as it is called at Baku, forms now the principal fuel in use on the southern Russian railways, on the Caspian and Black Sea steamers, etc., and seems destined ultimately to monopolize for a time the place hitherto held by coal in the navies of the world. Its use would nearly double the radius of action of a man-of-war, not to speak of other advantages which are dwelt on by the author.

The statistics of 1900 from Baku and North America concur in showing that, as the number of oil-wells increases, the output per well decreases proportionally. So too the depths at which the oil must be sought increase. The word "inexhaustible," so freely and frequently used, is therefore hardly applicable, even to these great oil-fields. L. L. B.

THE GEOLOGY OF GRAPHITE.

La Géologie du Graphite. *By* L. DE LAUNAY. *Annales des Mines*, **1903**, *series* **10**, *vol. iii.*, *pages* **50-86**, *with* 7 *figures in the text.*

The author adopts the eclectic view that the various forms of mineral carbon which occur in nature may in some cases be of inorganic, in others of organic, origin; and further, that in yet other cases their origin is complex. The work carried out by various distinguished chemists during the last 40 years shows that there are in reality several forms of graphite, differing in chemical properties and in the mode and temperature of formation.

A brief description, compiled from various well-known sources, is given of the graphite-deposits of Siberia (now abandoned), Ceylon, Bavaria, Bohemia, Styria and the Alps; and the industrial side of the question is relegated to an elaborate footnote, wherein the graphite-production of Austria during 1901 is stated at 34,000 tons, of Italy 10,300 tons, of Bavaria 9,000 tons, of the United States 2,600 tons, and Canada 1,700 tons. That of Ceylon is not stated.

The Siberian graphite, which occurs in nests and irregular masses in nepheline-syenite, is regarded by the author as of deep-seated and inorganic origin. He appears to agree generally with Mr. E. Weinschenk that the Ceylon graphite associated with granulites, garnetiferous gneisses, pyroxenites.

etc., is also of deep-seated and inorganic origin; but he regards Mr. E. Weinschenk's assimilation of the origin of the Bavarian and Bohemian graphite to that of Ceylon as problematical, to say the least. In fact, he points out how it is quite possible that the entire series of rocks, in which the graphite occurs in the two last-named countries, is a metamorphosed succession of sedimentaries.

The author feels no doubt whatever that most of the Alpine graphite-deposits are of organic origin, and he notes that in Liguria the graphite is associated with anthracite.

We have, then, in some cases to deal with graphites formed by the crystallization of carbon in molten magmas or sublimed from fumarolles amid acidic rocks and quartzes; and in other cases with graphites derived from the baking (by regional metamorphism or otherwise) of deposits of organic carbon. L. L. B.

THE AURIFEROUS DEPOSITS OF ROUDNY, BOHEMIA.

Das Goldvorkommen von Roudny in Böhmen. By P. KRUSCH. *Zeitschrift der Deutschen geologischen Gesellschaft,* 1902, *vol. liv., Protokolle, pages* 58-62, *with a plan in the text.*

The author claims that his is the first description, from the scientific point of view, of these deposits, which lie about 37 miles south-southwest of Prague, and some 9¼ miles east of Wotitz (a station on the Franz Josef Railway). They were worked from the fourteenth century onward until 1804, and have been recently opened up again after a lapse of well nigh a century. The old waste-heaps are about 100 feet high.

The district is reckoned to belong to the primeval-gneiss region of Bohemia; but the author found that the country-rock is really a granite, which in places assumes a gneissose structure. Or perhaps it would be better to say that we are dealing with three main varieties of rock:—(1) A normal grey biotite-granite, (2) a crushed, plicated gneissose granite, and (3) amphibolite or hornblende-rock, all three being traversed by dykes of haplite. A system of east-and-west fissures strikes through these rocks, usually dipping steeply northward; the fissures are only a very few inches wide, and are infilled with quartz and auriferous pyrites. There is usually an impregnation-zone extending into the country-rock, which is more or less altered thereby. As a rule the gold is combined with the pyrites, but it occurs also native (in an extremely fine state of division) in the quartz, or in the form of flakes or crystals on the walls of cracks within the quartz and pyrites. The proportion of gold varies from *nil* to 1 part per 10,000 of the vein-stuff. The thinnest fissures are richest, and the more finely-crystalline pyrites is richer in gold than the coarsely crystalline.

There appears to be little doubt that the deposits originated in the upward percolation of thermal waters carrying pyritous and auriferous particles in solution. These decomposed the granite in the neighbourhood of the fissures, and the reactions thus set up caused a precipitation of gold-bearing pyrites and gold-bearing quartz. The hornblende-rock resisted the decomposing action of the thermal waters more obstinately than the granite, with the result that it now contains practically no gold. It is evident that these processes took place before the intrusion of the haplite-dykes, and before the system of transverse, north-and-south, barren fissures began to form. L. L. B.

THE CORRELATION OF THE BOHEMIAN COAL-MEASURES.

Geologische Beobachtungen im Kladno-Schlaner Steinkohlenbecken. By Dr. K. ANTON WEITHOFER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1901, *pages* 336-338.

The author has ascertained, beyond a shadow of doubt, that the strata in the Kladno-Schlan coal-field, in Central Bohemia, are divisible into precisely the same groups and follow the same sequence as those in the neighbouring Pilsen coal-field. The Kladno main seam, 23 feet thick, at the base of the lowest division, which consists of a complex of grey sandstones, with here and there conglomerates and dark shales, 1,000 feet in thickness, corresponds to the Farewell (Radnitz) seam of the Pilsen basin. Above the grey sandstones in both areas comes the Red Shale group, at least 500 feet thick. The Roof or Schlan seam probably belongs to the Grey Shale group, for the Red Rocks prove everywhere to be barren, and they are not met with in the shafts which have struck the coal. Farther west, the Schlan seam becomes known as the Kounova seam, and is evidently identical with the seam which occurs at the base of the Grey Shale group of the Pilsen coal-field.

In conclusion, it is pointed out that the *Stegocephalus*-fauna described by Prof. Fritsch from the Bohemian coal-bearing areas is not of Permian, but of Upper Carboniferous age. L. L. B.

GEOLOGY OF THE KLADNO-RAKONITZ COAL-BASIN, BOHEMIA.

Geologische Skizze des Kladno-Rakonitzer Kohlenbeckens. By Dr. K. A. WEITHOFER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 399-420.

The lowest group of the Coal-measure series in this field consists mainly of grey grits, often coarsening into conglomerates, and characterized near their base by the occurrence of coal-seams homologous with the lowest seams of the Pilsen coal-field, among them being the Kladno Main seam. These "Grey Sandstones" or "Pilsen-Kladno" beds reach a maximum thickness of 1,300 feet and a maximum breadth of outcrop of 2 miles.

Next above these come the Lower Red Shales or Teinitzl beds, 800 feet or so thick at most, which in turn are overlain by the Dark Grey Shales or Schlan beds. The last-named are thought to exceed 650 feet in thickness, and they contain the top seam of the coal-field, called also the Schlan seam after that locality.

Satisfactory evidence has now accumulated of the existence, above the foregoing groups, of the Upper Red Shales or Lihn beds, which are to be correlated with the equivalent barren group in the Pilsen coal-field.

The author draws attention to the remarkable parallelism of the succession of alternating grey (and coal-bearing) and red (and barren) groups in Bohemia, Silesia, Saxony, Moravia, and the Saare basin. The vast area over which the uppermost Carboniferous and the succeeding Permian deposits are seen to present the same characters, is indeed striking. What may be called the key-zone, on account of its persistent recurrence at the same horizon right away from Silesia into Lorraine, is the felspathic arkose belonging to the Middle Ottweiler beds and containing remains of conifers (*Araucarites*). The source of its materials appears to have been the granite-and-gneiss massif of Bohemia, and it was possibly formed under

desert-conditions, certainly not under the climatic conditions usually postulated in regard to the Coal-measures. A curious point, moreover, is that remains of aquatic organisms are so far unfindable in the rocks described in this paper, except in immediate association with the coal-seams. Whence the author marches to the still bolder conclusion that practically the whole of this red and grey Coal-measure series represents æolian deposits formed in a vast region of steppes. Much detailed evidence is adduced in support of this contention.

The paper does not profess to deal with the mining industry of the Kladno-Rakonitz area, but in many cases the author mentions mines as being no longer worked. L. L. B.

THE STRATIGRAPHY OF THE CENTRAL BOHEMIAN COAL-BASINS.

Zur Kenntnis der geologischen Verhältnisse der Mittelböhmischen Steinkohlenbecken. By CYRILL RITTER VON PURKYNĚ. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt,* 1902, *pages* 122-125.

The strata in the Pilsen coal-field, especially in that portion of it which lies south of the Mies river, are disturbed by a deep trough-like depression running nearly due north and south, and attaining in its central portion depths of 2,000 to 2,600 feet, but shallowing in a step-like fashion eastward and westward. Dr. Weithofer, who was the first to describe this, also drew attention to the repetition of two groups of barren Red Measures respectively overlying the two groups of productive Grey Measures. This sequence is again proved by the deep boring lately put down north of Liehn, which gave a greater thickness for the Pilsen Coal-measures than any yet known in that area. From above downward we have: 500 feet of red and mottled marls and sandstones; 590 feet of grey marl-slates and grey and white sandstones (arkoses), with one seam and other traces of coal; 170 feet of red and mottled marl-slates and arkoses; 1,380 feet of grey and white arkoses and grey clay-slates, with nine coal-seams in the lowest portion; these are underlain by Huronian slates, at a depth of about 2,640 feet from the surface. The same section is shown by nearly all the other deep borings in the coal-field, and as the basin gradually shallows eastward and westward, the topmost group of strata and then successively the others disappear. So it is that the coal-shafts at Nýřan and Mantau in the west, equally with those at Sulkov and Lititz in the south-east, only go through the lowest group of Coal-measures. So too did it come about that mining-engineers in the 'seventies and 'eighties confused the lower with the upper barren Red Measures, regarding them as one-and-the-same group.

After discussing certain stratigraphical points in some detail, the author recommends the following nomenclature as applicable to both the Kladno-Schlan and the Pilsen coal-basins:—(1) Nýřan-Radnitz Series, comprising both the lower groups; and (2) Kounowa Series, comprising the two upper groups. L. L. B.

COAL IN DIABASE AT RADOTIN, BOHEMIA.

(1) *Das Vorkommen von Kohle im Diabas von Radotin. By* DR. W. PETRASCHECK. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt,* 1902, *pages* 55-57.

In the Radotin Valley, south-west of Prague, is a sill of diabase intercalated among the Lower Silurian graptolithic shales, and containing an-

thracitic coal. Many observers, during the last thirty years or so, have attempted to account for this occurrence; and, after a brief criticism of their explanations, the author points out that the coal is, chemically and physically undoubtedly an anthracite; that there are inclusions of it, as as big as a man's head, within the diabase, surrounded by a layer of highly decomposed diabase; that similar coal occurs in the calcitic fissure-veins which traverse the igneous rock; that the coal is evidently of later origin than the zeolites and calcite with which it is associated; that carbon in the shape of bitumen was brought by means of percolating waters from the overlying (highly fossiliferous and bituminous) shales into the fissures of the diabase; and that this precipitated carbon was gradually metamorphosed into anthracite. Similar occurrences of coal within igneous masses are recorded from other localities in Bohemia, and the author agrees with Dr. Katzer in assigning them to the same cause as that just explained.

L. L. B.

(2) *Zur Frage der Kohle im Diabas von Radotin.* By F. SLAVIK. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, **1902**, *pages* **194-196.**

There has been of late some controversy regarding the genesis of the [Silurian?] anthracites of Central Bohemia. Some of these have been found completely included within masses of eruptive diabase at various localities besides that mentioned in the title of this paper Hodkovičky, Řeporeje, Zabehlic, etc.).

Various writers have held that these anthracites are the fragmentary remains of true Coal-measures which have been utterly swept away by subsequent denudation. Dr. Petrascheck, on the other hand, regards them as derived from the bituminous and highly fossiliferous Upper Silurian limestones; but the present author will only admit this to be undoubtedly true of such anthracitic coals as occur encrusted with calcspar as infillings of fissures in the limestones. He points out the probability that the coal enclosed in the eruptive rocks of Radotin and other localities was brought along by the molten mass as it tore its way up through the Silurian and pre-Cambrian sedimentaries. In later times, in cases where the diabase was subjected to the decomposing action of weathering agencies, the carbonaceous particles would tend to concentrate in certain fissures, of which they would form the infilling, together with such minerals as calcite and zeolite.

L. L. B.

THE BROWN-COAL DEPOSITS OF NORTHERN BOHEMIA.

Ueber die Lagerungs- und Altersverhältnisse einiger Glieder der Nordböhmischen Braunkohlenablagerungen. By J. E. HIBSCH. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, **1901**, *vol. li.*, *pages* **87-92.**

As far as the Teplitz coal-field is concerned, at all events, the author's recent researches have convinced him that Prof. C. F. Naumann's view of the age of the brown-coal deposits, published in 1866, but since then generally disputed, is after all correct. That is, the brown coals, whether associated with the eruptive basalts and tuffs, or with the clays and sands containing quartzite-concretions below them, belong to one-and-the-same geological period, the Upper Oligocene and not to the Miocene. He tabulates the rock-succession as follows (in descending order):—

Periods.	Within the volcanic area of the Mittelgebirge.	In the Coal-basin west and north of the volcanic Mittelgebirge.
Lower Miocene.	Latest eruptive rocks. Fresh-water limestone of Kostenblatt.	Fresh-water limestone of Tuchorschitz, etc.
Upper Oligocene.	Eruptives and accompanying tuffs. Tuffite, clays, combustible shales. Brown coal-seam of Lukowitz, etc. Diatomaceous shales, tuffite.	Fire-clays of Preschen combustible coaly shales. Roof-beds (clays, shales, and sands). Brown coal-seam. Floor (mottled clays, in part).
Middle Oligocene.	Clays, sands, and sandstones, quartzite-blocks.	Mottled clays, in part. Sands, sandstones, and quartzite-blocks.
Upper Turonian.	Marl with *Inoceramus Cuvieri*, Sow.	

The so-called "brown coal-seam" is really split by thin partings into several seams, but the partings represent a very insignificant thickness in comparison with the enormous mass of the coal. Most of the few fossils found in it are plant-remains, but the Preschen fire-clays (from 200 to 500 feet above the coal) are rich in characteristic fossils. The brown coal is often broken through not only by basalts, but also by phonolites and trachytes and at those points is of course considerably altered. L. L. B.

NICKEL-ORE DEPOSITS ON THE SAXON-BOHEMIAN FRONTIER.

Ueber eine neue Nickelerzlagerstätte in Sachsen. By Dr. R. Beck. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 41-43.

In the first place, the author recalls his recent description of the nickel-ore which occurs along the salband of a diabase-dyke at Schweidrich in North-eastern Bohemia, and then states that towards the end of 1900, a similar occurrence was reported from Aeusserstmittelsohland, south of Schirgiswalde, exactly astride of the boundary between Saxony and Bohemia.

Geologically, the region is defined as that of the Lausitz granite, the vast mass of which is seamed by numerous diabase-dykes. The vertical section shown by a trial-shaft put down in the Sohland valley, is, in descending order, as follows:—Granite-rubble 10 feet; and ferruginous gossan passing downward into diabasic rock impregnated with sulphidic ores, 24 to 26 feet. Two trial-headings, 7 feet long, have been driven eastward and westward from the shaft-bottom and are completely within the ore-body.

The gossan consists chiefly of brown iron-ore, with irregular masses of black copper-ore and light-green strings of malachite, disseminated among the débris of decomposed diabase.

Lower down, come the copper-pyrites and nickeliferous magnetic

pyrites, very irregularly impregnated the diabasic rock: sometimes, however, they form fairly-large separate aggregates. The author saw, for instance, quite pure magnetic pyrites in nodules as big as a man's fist. The percentage of nickel is considerable, quite sufficient at all events to justify methodical working of the deposit. Actual analyses of the ore are, however, at present withheld from publication. The ore-bearing rock is a variety new to Saxony, and is described as a hornblende-olivine diabase, rich in spinel and biotite, and of gabbro-like habit. The mineral which was first to crystallize out was the dark-green transparent spinel: this was succeeded by the olivine, and that by the pyroxene and the hornblende. The crystals of these last two minerals are not seldom corroded, and in such a case are enclosed by bands or borders of pyrites, the ore appearing to dovetail into the crystal. The pyrites also occurs within the serpentinized olivines, or is closely intergrown with the biotite-crystals. The obvious conclusion is that the metalliferous ores are the latest-formed constituents of the rock. No room for doubt remains that the Schweidrich and Aeusserstmittelsohland deposits are genetically connected; and, further, they present an unmistakable analogy to the nickel-ore deposits of Norway, Piedmont and Canada. L. L. B.

ALLUVIAL GOLD IN BOSNIA.

Ueber die Zusammensetzung einer Goldseife in Bosnien. By DR. FRIEDRICH KATZER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol.* xlix., *pages* 277-280.

The gold-bearing alluvial deposits in the Pavlovac stream are near the town of Fojnica in Bosnia. There are traces of glacier-action in the neighbourhood, and it is probable that the deposits were originally due to the grinding effect of the ice. In some places they are rich in gold. One man in three days obtained 15 grains by washing the sand, and nuggets larger than a pea have occasionally been found. Waste-heaps where gold was formerly washed, and remains of old diggings can still be traced by the side of the stream, and may contain a little gold. Deposits of a later age, about 6½ feet thick, stretch on either bank, and fill up the inequalities of the river-bed.

Two samples of the soil were taken from different places, mixed, and sent to the chemical laboratory at Sarajevo to be tested. Of these 55 pounds were dried in the air, passed through a sieve, and sorted into eight different sizes, from pieces larger than an egg to grains $\frac{1}{50}$ inch in diameter. The two finest kinds were washed, and in the process two little pellets of gold weighing 0·14 grain were found in them. The sample was then freed from iron and other foreign substances, and classified into:—Coarse pebbles of micaceous-schist veined with milky quartz, a piece of silver-bearing lead-slag, showing marks of a peculiar smelting process, iron-slag, gœthite, mica-penores such as are found throughout the district, and refined lead containing silver.

A weight of 220 pounds of the alluvial deposit was found to contain 0·0376 gramme of gold, and a large percentage of mica, besides red hæmatite, magnetite, and gœthite. The slag shows that there were formerly smelting works in the district, although nothing is known of them. Silver and copper must have been worked, for the ores are still here. There is also brown iron-ore, which was till recently smelted in the furnaces at Fojnica.

Iron-slag has been found at a considerable elevation, and as no water-power to drive the furnaces was available, they must have been worked by man-power only, or by utilizing the pressure of the wind. Much of the iron-ore in Bosnia is so pure that it was deposited, probably, long before the other metals.

Next to mica, gœthite is most conspicuous in the Pavlovac deposits, and seems to have been originally pyrites, converted into gœthite in its progress down the valley. Magnetite is another noticeable feature of this deposit, and is found as crystals in the mica. Its frequent presence in these gold-bearing deposits is interesting, because it confirms the well-known geological theory that magnetite usually accompanies alluvial gold, and in Bosnia it is even regarded as a kind of indicator, pointing to the existence of the gold.

The origin of the gold found throughout the district has not been explained. Some connection may exist between it and the magnetite, or it may be derived from iron-pyrites or grey copper. The pyrites of a neighbouring district is comparatively rich in gold, and elsewhere in Bosnia grey copper containing gold is found. E. M. D.

COAL IN THE TRIAS OF BOSNIA.

Ueber ein Kohlenvorkommen in den Werfener Schichten Bosniens. By FRIEDRICH KATZER. *Centralblatt für Mineralogie, Geologie und Palæontologie,* 1902, *vol. ii., pages* 9-10.

The coal occurs as a very thin seam in sandstones belonging to the Werfen stage of the Trias, near the village of Lepoviči north of the famous iron-ore mines of Varesh. No plant-remains or other fossils have been found in the neighbouring beds, so far; the strata dip almost vertically southward (80 degrees), and strike west-north-west. The cóal, when dried in the air, crumbles up easily; it is black, with a lustrous conchoidal fracture, and dark-brown streak. It ignites with difficulty, burns with a short non-luminous flame, and leaves a great deal of reddish-grey ash. The latter, under the microscope, is seen to contain, besides its aluminous and iron oxide constituents, fragments of quartz and mica. The percentage of ash is 16·04, of volatile constituents 6·48, and of hygroscopic water 8·23. The calorific power, estimated by the Berthier method, is 4,256 calories. The mineral contains some sulphur, and does not coke.

The deposit is, unfortunately, of no industrial importance.

L. L. B.

THE IRON-ORE DEPOSITS OF HÜTTENBERG, CARINTHIA.

Der Erzberg bei Hüttenberg in Kärnten. By BRUNO BAUMGÄRTEL. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt,* 1902, *vol. lii., pages* 219-244, *with* 19 *figures in the text and* 2 *plates.*

The Erzberg (Ore-hill) at Hüttenberg in the north-eastern district of Carinthia has been the object of active mining industry since the days of the Romans, and its mineral wealth is by no means exhausted yet. The hill in question forms the extremity of a westerly spur jutting out from the mountain-range of the Grosse Saualpe, which itself trends north and south. As much discussion had arisen in regard to the genesis of the

ore-deposits, the author undertook in 1900 and 1901 a detailed petrographical study of the area, the fruits of which are now presented to the public. His paper is preceded by an elaborate bibliography, and before entering into the petrographical detail he gives a general sketch of the geology. The predominant rocks are schistose and banded, and used to be conveniently (if not too correctly) grouped all together as gneisses, there being a considerable mass of true gneiss among them. Intercalated among them are coarse-grained tourmaline-pegmatites and granular limestones; and with the main limestone-reef are chiefly associated the ore-deposits. The last-named, in a fresh condition, consist of granular aggregates of spathose iron-ore, often with pyrites as a secondary occurrence. Towards the outcrop the ore is weathered to brown hæmatite. Only occasionally are the iron-ores found to be intercalated among mica-schists, as the Bilbao miners' *dictum* "The limestone is the mother of the ore" appears to hold good in this district too. Taken as a whole, the metalliferous deposits form a stockwork, which exhibits no discernible relation whatever to the dip and strike of the bedded rocks: the ore-bodies are traversed by the tourmaline-pegmatite veins, and in fact these pegmatites appear to occur constantly in association with the iron-ores, but they are then kaolinized. The pegmatite-veins are undoubtedly intrusive, that is, of eruptive origin; and the author claims that, in contradistinction to the hitherto generally-accepted view that the Hüttenberg ores are a sedimentary deposit, it is to similar eruptive phenomena that the genesis of the ores can be traced back. He marshals at length the evidence which leads to this conclusion, his final statement being that the post-volcanic processes connected with the intrusion of a neighbouring granitic mass resulted in the partial replacement of limestone by iron-ores. L. L. B.

LEAD- AND ZINC-ORE DEPOSITS IN UPPER CARINTHIA.

Zur Kenntniss einiger Blei- und Zinkerzvorkommen der Alpinen Trias bei Dellach im Oberdrauthal. By OTTO SUSSMANN. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt,* 1901, *vol. li., pages* 265-300, *with* 5 *figures in the text and* 1 *plate.*

This elaborate memoir deals with the metalliferous mines of Kolm and Scheinitzen in the neighbourhood of Dellach (Upper Drave Valley), and with some isolated occurrences of ore near Pirkach. A short but adequate bibliography is followed by an historical sketch of the recently resuscitated mining industry in that region. Then comes a brief orographical description, and thereafter the stratigraphy and tectonics are considered in detail. Two parallel mountain-ranges run east-and-west, between the Gail and the Drave and the Möll and the Drave respectively; the rounded summits of the northernmost range belong to the old crystalline schists, while the bare serrated peaks and ridges of the southern range proclaim from afar the predominance of the Alpine Triassic limestones and dolomites. In fact, the river Drave in its westerly course may be regarded as demarcating the boundary between the two formations.

The older crystalline schists hereabouts are overlain by the Gröden sandstones and conglomerates, of Permian age. These are succeeded by Triassic strata, of a facies which is more of the North than of the South Alpine type, and these in turn by the Rhætic. Jurassic, Cretaceous, and Tertiary formations are conspicuous by their absence, but deposits of glacial origin play an important part in the geology of the district.

The ore-deposits of Kolm and Scheinitzen occur in the Muschelkalk limestones, some beds of which are gypsiferous and others bituminous. The ores of the Hermann adit are in higher beds (Wetterstein limestone); those of the Pirknergraben near Pirkach are in the *Cardita*-beds, and the isolated ore-bodies of the Marchgraben occur in Rhætic limestone.

At Kolm, the ore is really of the nature of a bedded deposit, the workable beds occurring in the neighbourhood of fissures in the Muschelkalk which are locally termed "veins." Galena is the predominant ore, and has withstood the usual agents of decomposition more successfully than the others. Most of the zinc-blende has been altered into earthy calamine, while comparatively pure brown hæmatite occurs in great cavernous masses in the upper part of the deposit and is probably the decomposition-product of the marcasite. The ores within the fissures or "veins" themselves are of less industrial importance than those which impregnate the "country." At Scheinitzen, the ores are chiefly zinc-blende and galena, and this appears to be the case also in the Pirknergraben and the Marchgraben.

The genesis of the deposits is discussed at considerable length, and there appears to be little doubt that the primary agents in their formation were thermal waters which carried along with them metallic particles in solution. Local circumstances, as for instance the presence of the impervious Wengen beds which both at Kolm and Scheinitzen dammed back the thermal waters, preventing their further uprise through the strata, modified the ultimate characteristics of the ore-bodies without altogether masking their common and probably contemporaneous origin. L. L. B.

THE COAL-BEARING TRIAS OF UPPER LAIBACH, CARNIOLA.

Ueber die Lagerungsverhältnisse der kohlenführenden Raibler Schichten von Oberlaibach. *By* Dr. Franz Kossmat. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 150-162, *with* 6 *figures in the text.*

The existence of coal in the Middle Trias, north of Oberlaibach, has long been known, and the district has been the scene of repeated exploration-work. Now again, very careful investigations are being made, with the view of determining whether the deposits would repay working. The outcrops occur in a narrow ridge which separates the Horjul valley from that of Podlipa: the last-named valley opens out gradually into the plain of Oberlaibach.

A detailed synopsis of the rock-succession is given, from which it appears that the coal is practically confined to the Raibl group, a series (at the base) of dark limestones interbanded with highly-fossiliferous black shales and coal-seams, and (in the Podlipa valley) pisolitic ironstones. But the main mass of the group is made up of vividly-mottled crumbly clay-slates and sandstones. It is overlain by the Hauptdolomit, and underlain by the St. Cassian Limestones and Dolomites.

The coal of the Lower Raibl group is of drift-origin, that is, it originated in masses of plant-remains floated in among marine deposits from a not very distant shore-line.

A bore-hole, put down at Drenovgrič to a depth exceeding 1,490 feet, proved the thickness of the entire Raibl group to be about 1,250 feet. West of this locality a shaft proved two main coal-seams: one, some 20 inches thick, almost immediately above the St. Cassian Dolomite, and the other

(a double seam from 2 to 3 feet thick) separated from the former by a barren mass of limestone-and-dolomite breccia and crushed marl. The average dip of the bottom seam is high—60 to 70 degrees, and one gathers that the strata are sharply folded into anticlines and synclines, and complicated by faults. Although the coal does not seem to lie anywhere at what we should consider great depths below the surface, the water from the overlying dolomite (held up by the impervious Raibl Series) constitutes a serious obstacle to mining enterprise. The coal is characterized as an anthracite, with a calorific power of 6,655 calories. It yields as much as 10·4 per cent. of ash, and pyritous impurities are not uncommon.

The pisolitic hæmatite already mentioned as occurring in the Podlipa valley would hardly repay working. L. L. B.

BORINGS FOR PETROLEUM IN HUNGARY.

(1) *Ueber die Aussichten der Petroleumschürfungen im Thale des Laborecflusses bei Radvany (in Oberungarn).* By DR. STANISLAUS OLSZEWSKI. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 353-356.

The author went specially to the neighbourhood of Csebinye and Radvany in county Zemplin, with the express view of ascertaining whether the geological structure of the district would warrant a systematic exploration for petroleum.

He describes the strata in detail, but appears to differ fundamentally from the officers of the Hungarian Geological Survey, in the age, which he assigns to them. He says that they all belong to the formation known in Galicia as the Saliferous Clay or Upper Oligocene. The Royal Hungarian Survey on the other hand, groups them as Magura Sandstone (Upper Cretaceous and Eocene), underlain by the Cretaceous Smilno and Belovesza shales, and the Neocomian Ropianka beds. He controverts emphatically the generally-received opinion that the natural oil observed in the neighbourhood of Radvany occurs in a belt which is practically the continuation of the petroliferous Ropianka beds near Dukla in Galicia. The difference of age is enormous, and moreover the strata of the Hungarian-Galician frontier strike across the strata of the Laborec valley (Radvany). Nevertheless, he does not deny that the district of Radvany has all the character of an oil-field, and though the boring, put down by an Austro-Belgian syndicate to a depth of 1,748 feet, was undertaken at a badly-chosen spot, it struck oil twice, but in small quantity.

By a detailed comparison of the Galician sequence with that around Radvany, the author concludes that oil in payable quantities will be found at much greater depths. He considers that it would be advisable for the Hungarian Government to give financial support to those who would undertake a boring to a depth of 4,000 feet or so, and he points out that the technical advance in the science of boring is so great that such an enterprise would be quite practicable. In Galicia borings of fairly large diameter are easily carried down to depths of 2,500 feet or more.

L. L. B.

(2) *Geologische Aufnahmen im Interesse von Petroleum-Schürfungen in den Comitaten Zemplén und Sáros.* By KOLOMAN VON ADDA. *Mittheilungen aus dem Jahrbuche der königlich Ungarischen Geologischen Anstalt*, 1902, *vol. xiii., pages* 145-198, *with* 1 *figure in the text and* 1 *plate.*

The author examined the area described in this memoir, on behalf of the

Hungarian Government, in his capacity as geological surveyor, in 1898. As that portion of the Magyar kingdom borders on Galicia, one of the problems that awaited solution was, whether the oil-bearing beds continue (in common with certain other formations) from Galicia into Hungary.

The general rock-succession is, in the first place, described as being (in ascending order):—(1) Lower, Middle, and Upper Eocene (mottled shales, sandstones, marls, etc.); (2) Lower, Middle, and Upper Oligocene (shales, sandstones, etc.); and (3) Quaternary alluvial formations. A detailed account is then given of the stratigraphy of the neighbourhood of Rokitócz, Zemplén-Driesna, and Sáros-Driesna, Alsö-Komarnik and Felsö-Komarnik.

With regard to the Rokitócz district, the author considers that a deep boring going down not less than 2,000 feet would strike the oil-bearing Lower Eocene, the Oligocene formation being there comparatively thin. In the neighbourhood of the two Driesnas the strata have the undulatory character which is the primary condition of the existence of a natural oil-reservoir, and, taking all the tectonic circumstances into account, a boring should yield successful results. The strata through which it should be put down, however, are restricted to a very small area and dip very steeply, nor do they occur in a particularly accessible spot. The remaining area of the Driesna district is not favourable for oil-prospecting. At Felsö-Komarnik, the Lower Eocene strata form the south-easterly prolongation of the rich petroleum-belt of Galicia: they cover here, it is true, but a small surface, though very promising for the oil-prospector. The best locality for a boring would be the area east of the confluence of the Dolina with the streamlets which run down from the Banchora range: the operations would have to be carried down to a minimum depth of 2,100 feet. A boring which was put down 1¼ miles north-west of Barwinek, struck a little oil at the depth of 1,770 feet, and this was associated with violent outbursts of natural gas. L. L. B.

(3) *Petroleumschürfungen in Ungarn im Jahre* 1900. *By* A. Walther. *Földtani Közlöny*, 1902, *vol. xxxii.*, *page* 154.

At Luch, in Ungh county, three bore-holes were put down. One, the Anna bore-hole, struck oil at a depth of 1,033 feet from the surface; the bore-hole was continued some 300 feet farther, when it was found that (accidentally) a trespass had been thereby committed on a neighbouring property, and further operations were suspended. The Török bore-hole reached a depth of 2,380 feet, but the diameter of the bore-hole had by that time contracted to such an extent that in this case also further work was stopped. The Lidia bore-hole was a more successful undertaking: oil was struck at a depth of 758 feet, and by December, 1900, 5 barrels of crude oil were being got thence daily.

At Felsö-Komarnik, in Sáros county, a boring reached on January 23rd, 1900, a depth of 2,083 feet from the surface. Oil and gas had burst forth 300 feet or so before this depth was reached, but after some weeks' pumping the supply gave out; and, the boring being thereupon carried down to the depth previously mentioned, another petroleum-reservoir was tapped which yielded regularly 5 barrels per day throughout the year.

Certain outbursts of gas and oil took place in the Izbugya-Radvány bore-hole, in county Zemplén, at the respective depths of 928 and 1,056 feet, but boring was being carried deeper down and operations were still in progress at the end of 1900. L. L. B.

THE JASZTRABJE PYRITES-DEPOSIT, HUNGARY.

Über ein Schwefelkieslager bei Jasztrabje in Ungarn. By J. KNETT. *Zeitschrift für praktische Geologie,* **1903**, *vol. xi., pages* **106-110**, *with* **4** *figures in the text.*

The lowlands of Nagy-Tapolcsan, known chiefly as a brown-coal basin, are the site of a Tertiary gulf, bordered to the westward by highlands of crystalline schist, and to the northward by the dolomite-hills. At the north-western head of this ancient gulf the author examined a deposit of pyrites about 20 inches thick in black clay, laid open by a railway drainage-cutting near Jasztrabje. The ore does not form a compact mass, but is rather cavernous in appearance (that is, contains large cavities), and the author is understood to suggest that it was deposited at the same time as the black clay and is to be associated with the decomposition of vegetable matter *in situ* in a swampy area. The strata, at one time horizontal, have now been folded into an anticline.

The ore-deposits would undoubtedly repay working, and points are suggested where it might be advisable to put down an exploration-shaft, with the view of determining the actual extent of the deposit. The area can hardly be very considerable, as the anticline is brought up sharply against the crystalline schists on the one hand, and against the Cretaceous dolomites on the other, but the possibility of a south-easterly extension is not excluded. Exploration-work might have the additional advantage of proving further occurrences of brown coal. L. L. B.

POLYHALITE IN THE AUSTRIAN SALT-DISTRICT.

Ueber die Polyhalite der Alpinen Salzberge. By AUGUST AIGNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* **1901**, *vol. xlix., pages* **686-689**, *with* **2** *figures in the text.*

Polyhalite forms an important characteristic of the rocks in this district. Although it does not vary much in composition, yet if considered in relation to the other rocks of the country, much light is thrown upon its origin. It occurs in three forms, the columnar, the foliated, and as red anhydrite.

In the first it is found in fragments from ¼ to 4 inches thick, and its chemical formula is $2CaSO_4,MgSO_4,K_2SO_4,2H_2O$. It is flesh-coloured, shading into brick-red, and has a pale resinous lustre. The little rods are always twisted, and their edges overlain with clay. This fragmentary crystalline polyhalite is usually scattered throughout the saliferous clay, but sometimes rests directly upon the salt-rock, upon which it must have been originally deposited as a sediment. The stratum is not very thick and follows the variations of that below it. If the polyhalite is dissolved artificially, as often happens in salt-mining, beautiful lumps of this crystallized anhydrite appear. Two samples from Hallstadt were analysed, and their chief constituents were calcium and 50 per cent. of sulphuric acid. Glauberite from Ischl showed a similar chemical composition.

The second form of polyhalite, the foliated, is found in conjunction with crystals of brown anhydrite. It is a beautiful dark red, and was at first supposed to be glauberite, but the writer proves the difference between them by comparing the chemical analyses of the two substances. Glauberite is another form of polyhalite, contains the sulphates of soda and lime, and is much richer in potash.

The third form of polyhalite is the red anhydrite. In the salt-district it is always found in grains, of a paler red than the columnar or foliated

varieties, and is probably a grey anhydrite, impregnated with polyhalitic salt, or rather an anhydrite which has been deposited in a solution of polyhalite. The red anhydrite occurs in such quantities at Aussee that it is used as manure. It contains much less potash and magnesia than the other two forms, but a large percentage of chloride of soda, or common salt, and this constitutes its value as manure. E. M. D.

METAMORPHISM OF THE GRAPHITE-BEDS IN UPPER STYRIA.

Der Metamorphismus der Obersteierischen Graphitlagerstätten. *By* Dr. K. A. Redlich. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 403-404.

The graphite-beds are now recognized as being of sedimentary origin, since the discovery in them of a Carboniferous flora. The writer discusses the question whether the present form of the carbon is due to dynamic metamorphism, or to contact with volcanic rock. There are two varieties of graphite, the soft and the hard. The first, according to Dr. Weinschenk, originated during great structural disturbance of the rocks, and has been crushed like coal by the pressure. The hard graphite may be compared to coal converted into coke, and brought in contact with volcanic rock; the one is the result of dynamic, the other of volcanic action.

The writer inspected the graphite-beds in the conglomerate at Sunk in Upper Styria: they are sometimes soft and foliated, sometimes hard and crystalline, chiefly the latter where the strata are much contorted. In the Bernese Oberland, the Jura, and the Styrian Alps the whole of the limestone, gneiss, and other rocks have not been subjected to transformation. Many of the Mesozoic limestones, in spite of the pressure, have preserved their original tough character, while others show crystalline structure in places where no volcanic influence is possible. Sometimes the strata have been exposed to the greatest pressures, without losing their characteristics, and the carbon has not been metamorphosed into crystalline graphite. Near Leoben there are two beds of graphite-slate. One of them lies directly upon the "white stone" which in its turn rests on the gneiss, the dividing line being sharply defined. The other is separated from it by a bed of micaceous schist, containing many fossils, and upon neither can the gneiss have acted in the way supposed. Below the graphite is a bed of serpentine embedded in the conglomerate, and it would be interesting to know what effect has been produced by it upon the graphite. E. M. D.

COAL IN THE TRIAS OF SOUTHERN TYROL.

Ueber ein Kohlenvorkommen in den Wengener Schichten der Südtiroler Trias. *By* Count H. Keyserling. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 57-61, *with 2 figures in the text.*

The locality of this occurrence, visited by the author in the autumn of 1901, is on the south-eastern slope of Monte Coldai, in the Civetta range, at a point near the junction of the Wengen tuffs with the Wengen dolomite. The former strata are much disturbed and faulted, and the main coal-seam crops out at an altitude of 5,350 feet, about 300 feet north of the disturbance. The main seam varies in thickness from 15 to 20 inches, dips 20 degrees south-south-eastward, and has a floor of dark limestone, but

in some places it is interbedded with clays and sandstones. The mineral is highly pyritous, and the author thinks that it is the outcome of the carbonization and decomposition of a layer of aquatic plants. He found similar coal-seams in the dolomite, and suggests that the currents bearing nutritive matter which encouraged the reef-building organisms (corals, calcareous algæ, etc.) to settle on that portion of the Triassic sea-floor, also floated thither the decomposing aquatic plants. The submarine volcanic eruptions, characteristic of the Wengen period, may have played some part in the carbonization, impregnating the plant-remains with sulphidic solutions.

The inhabitants of the neighbouring valleys had conceived rather extravagant hopes concerning these coal-seams, but it is now quite evident that the occurrence is not of industrial importance. L. L. B.

THE SCHNEEBERG ORE-DEPOSITS, TYROL.

Die Erzlagerstätte des Schneebergs in Tirol, und ihr Verhältnis zu jener des Silberbergs bei Bodenmais im Bayrischen Wald. By E. WEINSCHENK. *Zeitschrift für praktische Geologie*, 1903, *vol.* xi., *pages* 231-237.

Sulphidic lead and zinc-ores are of widespread occurrence, especially in the Eastern Alps, among the crystalline schists which mantle over the central granite-core. On the whole, however, the ore-deposits are too poor, and the transport-facilities are too restricted to admit of successful working. Thus it is that mines in the western part of the Eastern Alps have mostly long since been abandoned, while in the eastern part of that mountain-region many are still actively at work. Among the ore-occurrences known in the Tyrol, the Schneeberg deposit is one, the genesis of which has long formed the subject of more or less acrimonious discussion. The detailed investigations of Prof. Elterlein have shown that the Schneeberg ore is really of the nature of a vein-deposit. In this conclusion, the author emphatically concurs, but the main object of his paper is to refute the supposed analogy between the ore-deposits of Silberberg, near Bodenmais, in the Bavarian Forest, and those of Schneeberg. One of the peculiarities of the last-named is the occurrence of garnet, quartz, hornblende and mica, with chlorite, apatite and titanite, either in the form of nests within a normal sulphidic zinc-lead mass (blende, galena, iron-pyrites, magnetic pyrites, mispickel, boulangerite and fahlore), or sometimes mixed to a slight extent with the ore-body. The author regards the Silberberg deposit as having originated in a pyritic magma which welled up from great depths, and he refutes at some length Prof. Beck's objections to this hypothesis, declaring that further study of the local conditions has confirmed him in his original opinion. The Schneeberg deposit, on the other hand, is a normal vein of the Clausthal type. L. L. B.

THE ORIGIN OF THE MARBLES OF THE TYROL.

Die Tiroler Marmorlager. By E. WEINSCHENK. *Zeitschrift für praktische Geogolie*, 1903, *vol.* xi., *pages* 131-147, *with* 2 *figures in the text.*

The author reminds us in the first instance of Prof. Vogt's researches on the connection between the genesis of marble and its structure. That able writer distinguished between those varieties which are of contact-meta-

morphic origin, and those which are of dynamo-metamorphic or regional-metamorphic origin, concluding that the varieties which may be ranged in the first category are generally useless for ornamental purposes, as they are not sufficiently durable. The author's first-hand knowledge of Alpine marble-deposits led him to doubt the soundness, or at any rate the universal applicability, of Prof. Vogt's conclusions. He points out that much of the Carrara marble, the use of which is world-wide, exhibits the rectilinear granular structure typical of a contact-metamorphic origin.

He describes in great detail the chief occurrences of workable marble in the Tyrol, and shows that these were originally Palæozoic or Mesozoic fossiliferous limestones, through the massive beds of which basic eruptive magmas (near to gabbro in composition) tore their way, probably reducing the whole mass to a pasty semi-liquid condition, and therewith setting up all sorts of chemical reactions which in part explain the metamorphism of the sedimentary deposits into marbles and schists.

The important conclusion to be drawn from the economic point of view, is that the Tyrol marbles, both in structure and in mineralogical composition, are the result of intense contact-metamorphism. Contact-metamorphic marbles are of excellent quality, ranking indeed among the best known to commerce, and thus Prof. Vogt's interpretation of the connection between the structure and genesis of marble fails to hold the field.

L. L. B.

THE CAMPINE COAL-FIELD OF NORTHERN BELGIUM.

(1) *Quelques Mots à propos du Sondage d'Asch.* By BARON OCT. VAN ERTBORN. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie,* 1901, *vol. xv., Procès-verbaux, pages* 593-595.

Towards the end of August, 1901, the announcement was made that this boring had struck several seams of coal. It now appears that the Coal-measures were reached at a depth of 1,705 feet from the surface (or 1,440 feet below sea-level), that is, only about 33 feet deeper than might have been predicted from a general consideration of the geology of the country. The 1,705 feet of barren strata are made up of 558 feet of Cretaceous and 1,147 feet of Tertiary rocks, among which latter are several horizons of loose sands and some water-bearing sands. The Cretaceous is probably fissured here and there, but on the whole the conditions of the great mass of strata overlying the Coal-measures at Asch are not so unfavourable to industrial enterprise as might appear at first sight.

(2) *Études sur le Bassin houiller du Nord de la Belgique.* By X. STAINIER. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie,* 1902, *vol. xvi., Mémoires, pages* 77-120, *with* 3 *figures in the text and* 1 *plate.*

One point of considerable importance in connection with the new coal-field, in the Belgian province of Limburg, is that the seams already proved, though very rich, lie beneath so great a thickness of younger strata that their full value cannot be got out of them at present. It would be highly desirable to trace out a further extension of the coal-field, and there possibly the seams might be reached nearer the surface. In order to help to the attainment of this object, the author has studied the solution of those problems (associated with the new coal-field) that appear to him of the most immediate practical interest.

The author shows that the new coal-field is a prolongation of those of

Liége, Dutch Limburg, and the Wurm basin. The Lower Carboniferous massif of Visé can no longer be regarded as the northern boundary of the Liége basin: it is simply an islet surrounded on all sides by Coal-measures. It seems probable that the Lanaeken limestone is a similar islet, but that it marks the south-eastern border of the coal-field of Belgian Limburg. The coal-seams in this probably belong to a higher horizon than those in Dutch Limburg, one reason for the supposition being that they are much richer in volatile constituents. The amount of volatile constituents in coal is not, however, an infallible guide as to its relative horizon in the series.

The present distribution and localization of the Coal-measure massifs of western Europe and Britain is a result of the Hercynian crust-foldings (as was shown by Prof. Suess). That fact being conceded, it is possible to plot out, as the present author does, the areas along which Coal-measures may be looked for, from Aix-la-Chapelle to South Wales, and from Westphalia to Lanarkshire. The stratigraphical phenomena to which the Hercynian folds and subsequent cross-folds have given rise, and the consequent positions of the British and other North-west European coal-fields, are sketched by the author in some detail. He then proceeds to consider, in the light of these facts, the probable extent of the new Belgian coal-field. It may be expected to occupy an irregular triangle, considerably drawn out from east to west. He does not think that it will be traced beyond the Scheldt in Belgian territory, and the industrially-useful portion of the Coal-measures in the province of Antwerp will probably be confined to the north-eastern moiety thereof.

A good deal of mystery surrounds the new borings and trial-sinkings, and information as to the results achieved has only been obtainable privately, and then in a very meagre fashion. Piecing together the scattered fragments of information that he has been able to collect the author finds that the new Belgian coal-field is comparable in its general features with those of Shropshire and Southern Staffordshire, which lie on the northern border of the same anticline and like it overlie unconformably the Silurian. All these basins are of the lymnic (swamp, freshwater, or continental) type. The measures are apparently very regular, the dip is not steep, and the general strike is east and west. The seams are not very numerous, but in the matter of volatile constituents they differ from 18 to 44 per cent., and a seam of cannel-coal was struck in one of the first borings. The grey grits resemble closely those in the uppermost Coal-measures of England, which pass up into the red rocks that used to be considered as Permian. The boring at Eelen in the north of Limburg, at a depth of 2,034 feet, struck red sandstones, which continued down to 2,912 feet. These sandstones the author now regards as being either Permian, or of Upper Coal-measure age. If they are Permian, the salt-bearing beds of the Zechstein should be struck farther north, and thus Belgium would possess a salt-field as well as a new coal-field.

In an appendix, the author enumerates the proofs of an easterly extension of the British coal-fields, and in another appendix the proofs as to a north-westerly extension of the Westphalian coal-field.

(3) *La Houille en Campine. By* M. Lohest;

(4) *Raccordement du Bassin Houiller de la Campine avec celui de la Westphalie. By* A. Habets;

(5) *Prévisions relatives à l'Epaisseur et à la Nature des Morts-terrains, en Campine. By* H. Forir; *and*

(6) *Richesses minières domaniales en perspective.* By ÉMILE HARZÉ; *Annales de la Société Géologique de Belgique*, 1902, *vol. xxix.*, *Mémoires*, *pages* 81-119, *with 2 figures in the text and* 1 *plate.*

In accordance with the predictions of the geologists, coal has been struck in the Campine district, north of the Liége basin. In the neighbourhood of Asch, about ten different borings have reached the Coal-measures, after passing through some 1,600 feet of barren strata. The seams are very rich in volatile matter, and their general tendency to flatten out seems to indicate that one is here in the central part of a basin. Analysis of the coal shows that it is comparable to the coals richest in gas of the Mons basin. Premising that in a group of Coal-measures the gaseous seams are generally the uppermost, and that the depth and width of a coal-basin are proportionate to the richness in volatile matter of the seams which it contains, the first author infers that the newly-discovered basin is as deep as that of Mons (where the Coal-measures exceed 9,000 feet in thickness). He thinks that it is probably more extensive, for the synclinal folds in Belgium are broader the farther north they lie from the Ardenne axis of uplift; and so he would be inclined to recommend sinking for coal a considerable distance north of Asch, were it not for the probably-enormous thickness of overlying barren strata in that district. Two hypotheses are deducible from the known facts, namely:—(1) The Campine basin belongs to the same fold-series as that in which the Staffordshire coal-field lies; or (2) it belongs to the fold-series of the Yorkshire coal-field. Whichever of these hypotheses is the true one, further search for coal in a west-north-westerly direction is the proper course to follow, the thickness of the overlying barren strata at Antwerp and thence seaward being estimated at 1,150 feet or less.

The second author points out that the new coal-field is the Belgian parallel of the Essen basin of Westphalia, and believes that a similar parallel to the Bochum basin will be struck somewhere north-west of Visé.

With regard to the thickness of barren strata and quicksands through which it might be necessary to sink before reaching the coal, he admits that for technical reasons the Kind-Chaudron process is not applicable at depths exceeding 1,300 feet; but the Tomson process has been recently introduced in Westphalia with great success, and at Dorsten on the Lippe (for instance) about 2,300 feet of water-bearing barren strata have been sunk through without hindrance.

The third author deals in detail with the probabilities as to the thickness and character of the barren strata which conceal the Campine coal-field. The old Palæozoic surface appears to rise westward, whence it may be inferred that the farther one proceeds in that direction the less deep will it be needful to sink before reaching the coal. Borings are especially recommended in the district north of Antwerp and round about Knocke. Probably about 560 feet or so of comparatively dry Cretaceous rocks overlie the Coal-measures; and the Cretaceous in its turn is overlain by an average thickness (in the Campine district) of 1,150 feet of Tertiary and Quaternary deposits, among which are certainly some quicksands.

The fourth author examines the probability that much of the new coal-field underlies State domains, such as the military camp of Beverloo (the Belgian Aldershot). Meanwhile borings are being put down everywhere in the Campine district with such feverish haste that careful records of the strata passed through are out of the question, as far as these borings are concerned. The author considers that the State itself should undertake

a search for coal in its Campine domains, and should more particularly seek to determine the southern boundary of the coal-field. That the Belgian Government will not improbably include coal-mining among its multifarious functions, ere long, is illustrated by the Bill laid before the Senate to reserve as State mining-properties the lands adjacent to the camps of Beverloo and Brasschaet. L. L. B.

THE PYRITES-DEPOSITS OF VEZIN, BELGIUM.

Description des Gîtes métallifères de la Belgique: I.—Mine de Pyrite de Vezin. By X. STAINIER. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie,* 1902, *vol. xvi., Mémoires, pages* 1-15, *with* 7 *figures in the text and* 1 *plate.*

This memoir, the first instalment of a series dealing with the metalliferous deposits of Belgium, is devoted to an exhaustive study of the Vezin pyrites-deposits, situated on the northern rim of the Namur basin. For the first half of the nineteenth century oolitic hæmatite had been successfully worked in the Vezin district by several companies, and the pyrites was accidentally discovered in 1860-1862 in the course of exploration-work carried out in extension of some old mines. These had been discontinued, by reason of a disturbance in the strata, which is a factor of considerable importance in the tectonics of the district. It is conditioned by the Vezin fault, which appears to branch off from the great Landenne fault: the latter brings the Carboniferous dolomites down against the Silurian rocks. The mass of rocks between the two faults underwent at some remote period tangential pressures, crumpling up and upheaving the sedimentary deposits (Oolitic hæmatite among them), and into the fissure thus caused metalliferous solutions welling up from below brought what the author terms an undoubted vein-deposit of pyrites. The fissure was further filled with substances broken from or leached out of its walls, and with its northerly dip is brought up abruptly against the Vezin fault which is inclined southward. The argillaceous infilling of that fault probably prevented the further upward travel of the metalliferous solutions towards the surface. On the other hand, where these solutions met the hæmatite they percolated through it, following the general slope of the deposit, and altered it into pyrites. The author concludes that the Vezin ore-body is both sedimentary and metamorphic, and remarks that this is by no means an exceptional occurrence in the district.

Workings were carried on, on a small scale, in the years 1866-1868, but one does not gather from the author's observations that the metal-mining industry is now active there, or likely to be so again. L. L. B.

THE COAL-FIELDS OF THE PLATEAU CENTRAL, FRANCE.

Sur les Bassins houillers du Plateau Central. By A. DE GROSSOUVRE. *Compte-rendu de l'Association Française pour l'Avancement des Sciences,* 1902, *pages* 212-213.

On looking at the geological map of the Central Plateau of France, one notices at the first glance the long, nearly rectilinear, belt of coal-bearing beds extending from Moulins in the north to beyond Champagnac in the south, and continued thence by a series of small patches as far as St. Mamet.

No doubt the Decize coal-basin on the north is also associated with this belt. West of this Mr. Mouret has traced a similar belt, indicated by the "coal-fields" of St. Chamans (Argentat), l'Hôpital, Bougogles, Mazuras (south of) and Bosmoreau (north of) Bourganeuf. These two belts were at one time regarded as long, narrow channels, filled up by the deposits of the Stephanian age, but recent researches go to prove that they are nothing of the kind. Nor do they represent a crushed syncline: most of them, indeed, are mere fragments which have been preserved by sagging from erosion. The faults by which they are bounded are generally reversed faults, and the author concludes that the sagging was due to lateral pressure, the sunken masses being wedge-shaped, with the thin end of the wedge directed upwards.

The faults of Argentat and Mauriac are of much earlier date than the Stephanian age, and faulting must have there been repeated along the same lines after the deposition of the Coal-measures. L. L. B.

THE LOIRE COAL-FIELD, CENTRAL FRANCE.

Du Bassin de la Loire; sur les Tiges debout et Souches enracinées, les Forêts et Sous-sols de Végétation fossiles, et sur le Mode et le Mécanisme de Formation des Couches de Houille de ce Bassin. By C. Grand'Eury. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 521-538.

The author first of all remarks that the Loire coal-field is the most extensive [in depth] and the richest of those of Central France. He gives the following conspectus of the strata in ascending order:—

Series.	Thickness.	Number of Workable Coal seams.	Total Thickness of Coal.
	Feet.		Feet.
Basement-breccias...	1,312	—	—
Coal-bearing group of Rive de Gier	328	3	33
Intermediate barren-grits and conglomerates...	2,624	—	—
Productive series of St. Etienne	2,952	15	98
Avaize group, including the Rochettes seam ...	1,312	13	33
Upper micaceous conglomerates	1,640	—	—
Rothliegendes (?)	1,312	—	—
Totals ...	11,480	31	164

The lower groups occupy only part of the surface of the coal-field, and the upper cover a comparatively small extent—nowhere is the whole succession to be seen in one section. The author wishes to prove that the coal was formed *in situ*, basing this conclusion on the very numerous examples of rooted trees and of vegetable subsoils (under-clays) found in these Coal-measures. He proceeds to describe in detail the positions in which *Stigmaria*, *Syringodendron*, *Calamites*, *Calamodendron*, *Psaronius*, etc., occur therein, and draws attention to the variation in habit of the roots according to the nature of the soil in which they grew. On the whole, he describes the life-conditions of the Carboniferous flora as analogous to those of the vegetation of the Great Dismal Swamp in the United States. In the St. Etienne district, the under-clay is found not only at the floor of

the seams but also within the seams themselves, being in such cases very carbonaceous.

He then discusses the relation between the rooted trees and the coal-seams, and points out that at St. Chamond, for instance, the connexion is clear between the roots of *Cordaites* and the overlying coal formed out of the stalks, stems and leaves of the same plant.

At the same time he admits that, speaking generally, coal is mainly drifted vegetable matter. Yet all coal resembles more or less that which has been plainly formed *in situ*—the drifted débris are similar in character to the stems, etc., of the rooted fossil trees. He infers then that the constituent elements of coal were derived from marshy forests which were continuous with those actually occupying the basin of deposition, but extra-lacustrine, permanent, while on their floor humus was formed much as in peat-mosses. On the other hand, the conditions of the basin of deposition were those of a swamp-bottom at the present day; the remains of (fossil) plants which fell into the water at the edge of the swamp ultimately formed stratified deposits, and thus it is that certain coal-seams are in part derived from vegetation *in situ*, in part from drifted matter, much as the subaquatic peat of certain marshes of our own time. The comparative infrequency of coal formed *in situ* alone may be explained by the fact that the very position of the permanent forest-swamps prevented them from being buried soon enough by a protective covering of mineral sediments, and so they were in most cases swept away. We have only now remaining, from the peaty marshes of different geological periods, the strata which lay at the bottom, and were sealed up from destruction by the accumulation of silt, etc.

Returning to the conditions of formation of the Loire coal-field, it appears evident that the strata in which the fossil trees were rooted were in very shallow water. The repetition of root-bearing clays at intervals of 160 to 330 feet at Le Treuil, Montrambert, etc., shows that there were periods of slow sagging. When there is a great mass of strata, intercalated between the root-bearing clays, as at Beaubrun, La Grand'Combe, we may infer that subsidences were sudden and extensive. But the presence of a coal-seam of any considerable thickness implies a comparatively stable condition of the soil. The barren strata were, in the author's opinion, deposited in periods which followed on orogenic earth-movements of far-reaching effect. There is a striking contrast between the felspathic rocks of the Rive-de-Gier series and the quartz-mica conglomerates which form the base of the St. Etienne group, and this general substitution can only be accounted for by such orogenic movements. Near its northern boundary, the Coal-measure belt has been highly metamorphosed by siliceo-felspathic springs: these at St. Priest have formed regular bands of chalcedony within the Coal-measures. The author also adduces other evidence of the part played by eruptive magmas and thermal waters in the geological history of the coal-field.

He then enquires into the applicability of the delta-theory to the Loire basin, and finds that the Coal-measures were in part deposited by a stream which flowed in from the north or north-west, and in part by more rapid streams coming in from the south. A careful examination shows that the deposits dovetail into each other like wedges, while the coal-seams are fairly parallel.

L. L. B.

THE PISOLITIC IRON-ORES OF BRIEY, LORRAINE, FRANCE.

(1) *Des Gisements de Minerais de Fer oolithiques de l'Arrondissement de Briey (Meurthe-et-Moselle) et de leur Mode de Formation.* By GEORGES ROLLAND. *Comptes-rendus du huitième Congrès géologique international,* 1900 [1901], *pages* 664-672, *with plates X-XI. (maps).*

This memoir is complementary to the papers already published by the author in the *Comptes-rendus* of the Paris Academy of Sciences. In 1898, he drew attention to the discovery that the pisolitic ore-belt long worked in the former department of the Moselle extends beneath the district of Briey into the department of the Meuse. This discovery was the outcome of two series of borings (161 in all), put down during the years 1882 to 1886 and 1892 to 1900.

Taking into account the present state of the arts of mining and metallurgy, the new area of workable ore may be estimated at 98,840 acres, nearly the whole of which has been already parcelled out into mining concessions On maps, which gave the depths from place to place of the floor of the grey ore-bed, the author plotted out approximately the curves of equal thickness and equal richness and equal tenour (in iron); the maps so constructed show that neither the thickness nor the distribution of the ore bears any general, regular relationship to the subterranean topography or to the position of the faults.

The variations in thickness show that during the deposition of the ores little synclinal basins were formed at the points where the slope of the great basin was steepest, and the order of superposition of the strata indicates that the Jurassic topography differed entirely from the present topography. The author's general conclusion is that the pisolites are a sedimentary formation of continental origin.

The maps which accompany the paper give a clearer picture of the new iron-ore field and its characteristics than could be built up from many pages of description. L L. B.

(2) *Le Gisement de Minerai de Fer oolithique de la Lorraine.* By FRANÇOIS VILLAIN. *Annales des Mines,* 1902, *series* 10, *vol.* i., *pages* 113-220 *and* 223-322, *with 6 figures in the text,* 2 *vertical sections and* 8 *plates.*

The nine chapters of this elaborate memoir and its wealth of illustrations form a perfect cyclopædia of all that is at present known regarding the pisolites of French and German Lorraine, and the bordering districts of Luxemburg. It is true that the author leaves out of count the Nancy basin, as being familiar and as having failed to give rise to any interesting discoveries of late years; whereas the Briey basin, to which he devotes considerable attention, has only been thoroughly investigated as recently as 1894-1899.

The annual production of the entire region reached in 1900 the total of 18,000,000 tons of ore. The workable area is estimated at about 260,000 acres, and the amount of available ore at 5,000,000,000 tons. The age of the rocks in which these pisolites occur is undoubtedly Oolitic: the strata at the surface belong to the Bathonian division of that system, but the ores have to be reached by means of shafts in many cases 600 and 800 feet deep. No less than seven French companies have put down or are putting down such shafts, although in former days the State used to work the ores by means of adits driven in the hillsides, or even opencast. Such indeed are the methods of working still carried on in Luxemburg, which

duchy produces a third of the total annual output. In German Lorraine many of the mines have to be drained by powerful pumping-engines.

Details are given of various borings, showing several seams of pisolite intercalated among limestones and marls. When completely developed the ore-formation ranges between 80 and 160 feet in thickness, but it thins out gradually to nothing towards the edges of the basins. In the Nancy district, the thickness never exceeds 33 feet. The good average quality of ore contains about 42 per cent. of metallic iron and 2 per cent. of phosphoric acid: some extraordinarily good samples contain as much as 60 per cent. of metallic iron.

In his preamble to an exhaustive review of the literature of the subject, the author points out that all writers have invariably laid great stress on the faults which cut through these Lorraine deposits, while at the same time explicitly or implicitly asserting that the aforesaid faults played no part in the distribution of the ores. The author, however, holds a diametrically opposite opinion, as to some of the faults at any rate, which he terms *failles nourricières* ("feed"—or "supply-faults," if we view the ore in the light of material that is "fed" or "supplied" to a particular locality). He appeals to the late Mr. Godwin-Austen's theory, more recently expanded and illustrated by Prof. Marcel Bertrand, of the superposition and repetition through successive geological ages of synclinal and anticlinal folds in a given region, and a similar repetition of fractures along the same lines. The rich ore-deposits, in the present instance, occur in the synclines, and are literally basins.

The hypothesis of "supply-faults" is enunciated as follows:—

(1) The iron-ore was brought to the sea-bottom by fissures in the earth's crust through which thermal springs welled up, carrying the iron chiefly in the form of carbonate. This carbonate was subsequently decomposed by the sea-water, and threw down a pulverulent precipitate of oxides which enriched the contemporaneous sediments.

(2) When the deposit was abundant, a bed of ore was formed not only in the neighbourhood of the thermal springs, but extended over an area which was dependent on the strength of the currents and the topography of the sea-bed, as well as on the amount of ferruginous material.

(3) It is inferred that the most abundant emissions of ore took place precisely through those fault-fissures which are still conspicuous by their downthrow, in comparison with the other faults. It is not asserted that the present surface-relief of the deposits is actually identical with that of the Toarcian sea-bed, but that it is very similar to it.

(4) The cessation of the ferruginous thermal springs marks the close of the Toarcian era of dislocation and the beginning of the Bajocian—an era of tranquil deposition, as shown by the fairly uniform thickness (often more than 100 feet) of the micaceous marls which mantle over the entire ferruginous formation.

The third chapter is taken up with the description of the Longwy basin, the fourth with that of the Landres basin, the fifth with that of the Ottange-Tucquegnieux basin, and the sixth with that of the Orne basin. In the seventh chapter, the author deals with the origin of the silica and alumina contained in the ores and with that of the carbonates. In the eighth chapter he shows that the phosphorus associated with these ores is not, as was long believed, of organic origin; and in the ninth chapter he emphasizes and re-asserts his hypothesis of "supply-faults," which themselves originated in eruptive phenomena.

L. L. B.

MINERALS OF CENTRAL FRANCE.

Excursion à quelques Gîtes minéraux et métallifères du Plateau central. *By* L. DE LAUNAY. *Comptes-rendus du huitième Congrès géologique international,* 1900 [1901], *pages* 938-970, *with* 11 *figures in the text.*

Pisolitic Iron-ores of Berry.—These ores occur scattered about in pockets over a radius of about 25 miles around Bourges. They are worked by shallow pits which are necessarily sunk in a rather haphazard way, as it is not always certain where or whether the ore will be met with, and the workings are being constantly shifted from one locality to another. The total output for 1900 is estimated at about 30,000 tons, and the number of workpeople employed at the seven or eight mines now in operation is 50 or so.

These ores are in no way connected with those of Mennetoux, of Neocomian age, in the north of the department of the Cher, of which Bourges is the chief town. At Mennetoux, mining has been re-started quite recently and the industry has developed enormously from 1899 onwards. In that year the output was 30,000 tons.

The average percentage composition of the pisolitic ores is as follows:—Peroxide of iron, 58·70; lime, 1·20; alumina, 12·10; silica, 10·60; phosphorus, 0·20; sulphur, traces; manganese, not estimated. But other analyses show that the percentage of alumina in some cases is as high as 23, and that of silica 11·5 (ores of St. Florent).

The so-called "siderolithic" formation, to which the ore-pockets belong, extends over a vast stretch of country, and is in part overlain by lacustrine limestones correlated with the Oligocene limestone of Brie. The formation has all the characteristics of a shallow-water deposit, laid down at a time (when sedimentation was not very active) following upon a long period of upheaval. The pisolites are associated with mottled clays, which in places contain dark-yellow or red rounded alumino-ferruginous nodules, and there is an almost insensible gradation from these into the pisolites. The last-named are especially abundant at the base of the clay. The pockets occupy hollows eroded out of the Jurassic limestone, which itself shows signs of intense alteration around these hollows. The author does not believe that the hollows were formed by any deep-seated phenomena of dislocation. On the other hand, he holds that the siderolithic clays are not mere decalcification-products of the limestone due to pluvial action, but that they must have been formed in pools or lake-basins, wherein a good deal of carbonic acid (derived perhaps from thermal springs) was in solution. The presence of this acid would be a potent factor in eroding hollows out of the limestone-bed of the lake.

Amblygonite-mine of Montebras (Creuse).—This mine, formerly worked for tin, is now the sole existing source of amblygonite, a mineral utilized for the production of lithia, of which it contains from 6 to 8 per cent. The author remarks, by the way, that the lithia-industry is practically the monopoly of Bonn-on-the-Rhine: besides amblygonite, lithia-bearing micas are there used up, imported from Moravia, from Chédeville near Limoges, and from Zinnwald in Saxony. The mineral output of Montebras is about 100 tons *per annum.* For some time the amblygonite was got by simply overhauling the waste-heaps of the old tin-mine, and only recently have workings been begun below bank. Even so, they have not as yet gone below the superficial kaolinized belt, where the rocks are altered by all sorts of secondary action, or have been disturbed by the ancient tin-workings. The country-rock would appear to be a porphyroidal granulite with primary

quartz: this is seamed by veins in which amblygonite is associated with quartz and tinstone. Moreover, the entire mass of the granulite is more or less stanniferous. The principal "vein" is some 40 feet long, with a maximum breadth of 13 feet.

Antimony-mine of Montignat (Allier).—This mine is more interesting, as being a sample of the many antimonite-deposits scattered about the Central Plateau of France, than important industrially. It has been worked and then abandoned again several times over, since it was first started in 1783. The ore occurs in a stockwork of quartz, in a dyke of granulite which cuts through a granite-gneiss on the right bank of the Cher, 1¼ miles above Chambouchard. The granulite strikes 40 degrees north, and dips steeply eastward. The antimonite-veinlets are extremely irregular, and their thickness varies from ¼ to 1 inch. Sometimes mispickel is associated with them: very rarely the antimony-ore is found to swell out into lenticles several inches thick. The age of the deposit is intermediary between the Dinantian and the Stephanian (stages of the Carboniferous system). The author proposes shortly to publish a detailed monograph on the antimony-ores of the Central Plateau.

Kaolin-mine of Les Collettes (Allier).—These mines are worked in the decomposition-belt of a white-mica granite or granulite, which forms an isolated mass amid the mica-schists. The workings have proved the limit in depth of the kaolinized belt, and therefore disprove definitely Prof. Daubrée's theory that kaolinization is an ancient phenomenon due to the action of stanniferous fluorides. It is evidently connected, on the other hand, with the recent action of surface-waters. Three main reefs of quartz stand out in the opencast workings, and where they are intersected by cross-veins, kaolinization has been most active (owing to the more rapid circulation of percolating waters), reminding one of the enrichment of metalliferous veins at intersections. The classic kaolin of St. Yrieix, near Limoges, is purer than that of Les Collettes, because it is the decomposition-product of a pegmatite, instead of being that of a granulite.

St. Eloy Colliery.—This mine is on the strike of a long rectilinear belt of Coal-measures which cuts diagonally across the Central Plateau. This is not simply a chain of ancient lakes, or the mere infilling of some ancient basin: it is generally transverse to the ancient folds, and appears to have resulted from a great dislocation which took place at some time between the Dinantian and Stephanian epochs. The Coal-measures underwent, moreover, intense transverse compression extending over a long period, with the result shown in the author's sections, where the contortions, the overfolds, and the irregular thickening and thinning of the coal-seams are extreme. The strata are mainly shales and grits, conglomerates being poorly represented: when such do occur, they are mainly made up of gneiss-pebbles. The coal is mostly semi-lignitous, burns with a long flame, and is good for household purposes: the upper and middle seams alone are worked, the lowermost seam being still unworked.

On the north the coal-belt narrows suddenly and all but disappears between St. Eloy and La Peyrouse, but its course can generally be followed by tracing a blackish clay: at Montmarault the Coal-measures re-appear with a breadth of 330 to 500 feet, and broaden out more and more until abreast of Noyant they reach their maximum width in this region, that is, more than 2 miles.

Phenomena of contact-alteration of coal are noticed at St. Eloy. There

is a rock termed "white bind" or *gore* (which plays a part similar to that peculiar to the porphyrites of Commentry) particularly in connection with the top coal-seam. At the contact, the coal is hardened, graphitized, and contains small veinules of crystallized baryte (no doubt derived from the orthoclase-felspars of the "white bind").

Asphalt-mines of Pont du Château (Puy de Dôme).—Over an area measuring about 100 square miles, between Clermont-Ferrand, Riom, and the river Allier, bitumen and asphalt-deposits are numerous amid the Tertiary beds associated with the younger basalts. North of the area of basaltic eruption, the Tertiary strata contain no bitumen, but south of it bitumen is found in the *Helix-Ramondi*-limestones (Aquitanian) of Pont du Château and Les Roys, in the Upper Tongrian marls of Puy de la Bourrière, in the sands and arkoses of Lussat and L'Escourchade, etc.

The asphalt in the Pont-du-Château mines occurs as a distinctly localized impregnation in a bed of concretionary *Helix-Ramondi*-limestone (from 13 to 20 feet thick) overlain by grey marly limestone, and underlain by other marly limestones. The impregnation is manifestly of later date than the deposition of the limestone in which it occurs, and its concentration there is probably due to the argillaceous character of the overlying and underlying beds. The asphalt appears to have come from below, as indicated by the presence of small veins of it in the floor of the limestone-bed. A sample of the asphalt, analysed at the Paris School of Mines, was found to contain 2·69 per cent. of sulphur.

The Manganese-mines of Romanèche (Saône et Loire).—These mines show an annual output of 11,000 tons. The ore contains neither phosphorus nor sulphur, and hardly a trace of arsenic; it is chiefly used for metallurgical purposes, but some of the richer ore (containing 55 per cent. of manganese) is sold in the form of powder to glass-factories. The deposits were discovered in 1750, and worked for the first time in 1823. At present, two kinds of ore-bodies are being worked:—(1) A primary vein-deposit in granite, and (2) a mass which occurs amid the sedimentary strata of Trias, Rhætic, and Toarcian age that abut on the granite, and is manifestly of secondary origin.

One peculiarity of the psilomelane of Romanèche is the constant association of baryte with the ore. Among other associates are fluor-minerals and silica. Calcite is entirely absent from the vein-deposits, but occurs in the secondary deposits. Another peculiar feature is the gradual replacement of the manganese by iron, at depths varying between 260 and 330 feet. At 260 feet, the ores only contain 8 per cent. of manganese. Down to this depth, the greatest so far worked in the mine, the granite country-rock is completely decomposed, and the *Gryphæa*-limestone in which some of the secondary deposits occur crumbles to dust. The abundant mine-waters are highly charged with sodium and magnesium chlorides.

For further details regarding most of the deposits described in this memoir, the author refers the reader to his *Traité des Gîtes minéraux et métallifères* and the bibliographical list which accompanies it.

L. L. B.

THE KAOLIN OF ST. YRIEIX, FRANCE.

Observations sur les Kaolins de Saint-Yrieix. By L. DE LAUNAY. *Annales des Mines*, 1903, *series* 10, *vol. iii.*, *pages* 105-115, *and* 5 *figures in the text.*

The author does not agree with those who attribute to kaolin a deep-seated origin, but regards it as a product of surface-decomposition. He claims the deposits herein described as so much additional evidence in support of his views.

The kaolin-quarries of St. Yrieix occupy a belt some 12 miles in length to the east of that town, ranging towards Coussac-Bonneval and Mongibaud along a fairly level plateau, at an average height of 1,200 feet above the sea. These quarries have been renowned since 1765 for the superior quality of the kaolin which is got from them; but they are being gradually worked out, and the annual production is now much reduced. The increased cost of working, the exhaustion of the deposits in depth (they are rarely worked more than 130 feet below the surface), and the competition of Cornish kaolin, are all factors which have conduced to this diminution.

The mineral is derived from the decomposition of pegmatites properly so-called, and also from exclusively felspathic-rocks such as are sometimes associated with granulites: these occur as veins seaming the crystalline schists. Some of the kaolin-"veins" occur in the midst of amphibolites (hornblende-rocks), the blackness of the latter showing up the brilliant whiteness of the former: such is the case at Marcognat, of which quarry the author figures a section taken in 1902. The purity of the mineral is due to the fact that, in the undecomposed vein, felspar occurred alone or associated only with quartz, but in any case quite free from mica.

L. L. B.

BROWN COALS IN THE PROVINCE OF POSEN, PRUSSIA.

Beitrag zur Kenntnis der Braunkohlenablagerung in der Provinz Posen. By — KRUG. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 53-55, *with* 1 *figure in the text.*

The brown coals which have been worked of recent years near Stopka, about 10 miles north of Bromberg, are of considerable importance for Eastern Prussia, as they have given rise to a flourishing mining industry. The age of the seams remains as yet undetermined: they are underlain by white micaceous quartz-sands, and overlain by blue and grey clays (sometimes mottled with red and yellow bands). The last-named constitute the so-called "Posen fire-clay," which Dr. Berendt considers to be of Miocene age. If his assumption were correct, the brown coals would then probably be Uppermost Oligocene or Lowermost Miocene. Under about 60 feet of clay come five coal-seams, the higher of which vary in thickness from 4 inches to 3 feet or more, while the lowest is 10 feet thick. They occur in a saddle (anticline and syncline) which extends for more than a mile and a quarter from north-west to south-east. The crest of the anticline rises to within 65 feet of the surface, but the crest is itself undulating, forming thus several small basins. Borings have shown that the seams on the northern limb dip much more regularly than on the southern: further investigation shows the seams on the south to be completely turned over, and to be so "smashed up" that the coal is ground to dust.

The above-described Tertiary strata are overlain by the Glacial Drift (sands, gravels, and boulder-clays), and the Drift is, of course, thickest

(150 feet) where the Tertiary is least disturbed and the coal-seams are practically horizontal. A small but persistent seam of lignite, about 1 inch thick, occurs in the Drift.

It seems possible that the abrupt folding of the Tertiary strata is assignable to the "thrust" or "push" exerted by the advancing ice-cap during the Glacial Period. L. L. B.

THE MAIN EASTERN FAULTS IN THE AIX-LA-CHAPELLE COAL-FIELD, GERMANY.

Die östlichen Hauptstörungen im Aachener Becken mit besonderer Berücksichtigung ihres Alters. By — JACOB. *Zeitschrift für praktische Geologie*, **1902**, *vol. x., pages* **321-337** *and* **1** *plate.*

The three great faults described in this paper strike practically across the strata, from south-south-east to north-north-west, with a general north-easterly hade. They are known as the Münstergewand, the Feldbiss, and the Sandgewand. Between the two last-named another great fault-line, known as the western main fault, has been recently discovered in the Nordstern colliery.

The evidence furnished by 63 bore-holes, full details of which are appended to the paper, as to the varying character and thickness of the Tertiary cover, leads the author to the following conclusions. The strata continued to sag along these fault-lines even after the deposition of the Miocene beds, but on the other hand faulting must have started long before then. The downthrow within the Tertiaries is less than that proved within the Coal-measures: for instance, a difference of level in the latter of 1,050 feet, becomes only 426 feet in the Upper Oligocene marine sandstones. This is explained on the hypothesis that sagging took place repeatedly along these fault-lines, to some extent long before the deposition of the Tertiaries, and to some extent after the deposition of the Miocene.

The circumstance that the Coal-measures formed an even surface at the time when the Tertiary rocks began to be laid down in the Aix-la-Chapelle region does not invalidate these conclusions. The denudation extending over the long time-interval between the Upper Carboniferous and the Upper Oligocene was sufficient to pare down such inequalities of level as may have arisen through the sinking of different "fault-blocks." L. L. B.

THE SEARCH FOR COAL IN SAXONY.

Wo könnte in Sachsen noch auf Steinkohle gebohrt werden? By K. DALMER. *Zeitschrift für praktische Geologie*, **1902**, *vol. x., pages* **223-225**; *and* **1903**, *vol. xi., pages* **121-123**.

The author considers that within the next 30 or 40 years many of the Saxon collieries must needs be shut down, owing to the exhaustion of the deposits. Compensation for this diminution in coal-output can only be sought by opening up fresh coal-fields, and the question then immediately arises as to what localities are likely to afford some prospect of successful boring-operations.

The boring put down by the Prussian Government in the years 1880-1886, at Schladebach, near Merseburg, struck the Upper Coal-measures at a depth of 2,102 feet, and passing through a thickness of these measures of no

less than 3,247 feet (all comparatively barren) was stopped in Upper Devonian shales. Another boring, which did not go down to quite so great a depth, at Dürrenberg, showed a vast thickness of Upper Carboniferous rocks there also, but again without any coal-seams. Various stratigraphical reasons are adduced to show that the Coal-measures really extend much farther than is generally suspected in the eastern part of the province of Saxony and thence into the Leipzig district within the kingdom of Saxony itself, until their further extension is barred by the concealed Archæan ridge which stretches from Leipzig to Riesa. No borings have as yet been carried far enough down in the district north of Leipzig to prove the Coal-measures, but the experiment seems worth trying, and the author recommends also that boring-operations should be started in the northern part of the Permian basin of Central Saxony, and especially between Borna and Lucka. One could hardly hope for definite results without going down to a depth of about 2,000 feet.

With regard to the Erzgebirge basin, an extension of the known coalfields can only be looked for in its southern part, and the author holds that the best locality for a trial-boring would be somewhere to the south of Werdau. Here again, it would be necessary to go down to a depth of at least 2,000 feet. Another good locality, for which reasons are adduced, would appear to be Coselitz, between Riesa and Elsterwerda.

L. L. B.

MARINE FOSSILS IN THE COAL-MEASURES OF UPPER SILESIA, PRUSSIA.

Neuer Fundpunkt von mariner Fauna im Oberschlesischen Steinkohlengebirge. By R. Michael. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1902, *vol. liv., Protokolle, pages* 63-66.

The uppermost group of the Carboniferous in the province of Upper Silesia contains exclusively brackish-water or freshwater forms of life. So too does the Middle or so-called "Saddle" group, important in Upper Silesia for the number, thickness, and quality of its coal-seams. In the Lower or Border group (correlated with the Ostrau series) marine organisms come in. They have been found at many different horizons in all the deep borings in the western portion of the field. The marine fauna too has been proved immediately below the [bottom] seams of the Middle group, in the main "saddle" which strikes eastward from Zabrze, arross Morgenroth, Königshütte, and Myslowitz into Russian territory.

In this paper, the author describes the occurrence at Radzionkau, of three marine faunas at as many different horizons, brackish-water organisms (such as *Anthracosia*) occurring at an horizon between the two lowermost marine faunas. Various species of *Productus, Lingula, Aviculopecten, Nucula, Leda, Orthoceras, Bellerophon, Pleurotomaria,* and one trilobite *(Phillipsia)* were obtained, besides undeterminable fragments of goniatites.

L. L. B.

THE PERMIAN AND TRIAS OF THE RUHR COAL-FIELD.

Zur Kenntniss der Dyas- und Triasablagerungen im Ruhrkohlenrevier. By Gottfried Müller. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 385-387.

The cores of a boring at Kirchgell Heath, south-west of Dorsten, examined by the author, showed 16 feet of porous dolomite with undoubted

Permian fossils, at a depth of 1,404 feet from the surface. At the Gladbeck colliery, the cavities in similar dolomite are in part encrusted with copper-ores, and the dolomite is underlain by 3 feet or more of thinly-bedded anhydrite and gypsum. In the Springfield (Kirchgell) boring, the basement of the Permian is formed by a conglomerate about 20 inches thick, and below this comes 30 feet of red-stained shales and clays, followed by the uppermost coal-seams.

In the Vreden boring, near Ahaus, rock-salt is proved between the depths of 1,285 and 1,370 feet. It may be inferred to be of Keuper age, and below it comes some 1,600 feet of Bunter Sandstone.

At the Preussen II. pit, below 1,170 feet of Cretaceous and Neocomian beds the Red Rocks are struck: the uppermost of these are shown by the plant-remains to be of undoubted Rothliegendes age. Lower down occur shales with striations which the author believes to be "palæoglacial." He adduces the evidence which tells against their being slickensides or thrust-phenomena. These shales are below the basement-conglomerates of the Rothliegende, and it is pointed out that an enormous period of time must have elapsed between the first deposition of that formation and the last deposition of the highest seams of the underlying Gas-coal group.

L. L. B.

THE NEWER STRATA OVERLYING THE RUHR COAL-FIELD, GERMANY, AND THE WATERS WHICH THEY CONTAIN.

Ueber die Deckgebirgsschichten des Ruhrkohlenbeckens und deren Wasserführung. By DR. A. MIDDELSCHULTE. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate*, 1902, *vol. l.*, *Abhandlungen*, *pages* 320-345.

In the east of the Ruhr coal-field, the Carboniferous strata are immediately overlain by the Upper Cretaceous, but in the west the Zechstein (Permian) and Triassic Bunter Sandstone Series intervene between the Chalk and the Coal-measures. At Gladbeck, the last-named are reached at a depth of 1,460 feet from the surface, 416 feet of which represent the thickness of the Bunter and about 27 feet that of the Zechstein. The Coal-measures are directly overlain by a 2 feet band of dark-grey micaceous bituminous shale, containing plant-remains. The Zechstein Limestone on the top of this is very sharply marked off from it. The shale is regarded as the equivalent of the Kupferschiefer, and its presence has been proved in many other sinkings, but nowhere in the Ruhr basin does it contain metalliferous ore. The thinly-bedded, tough, light-grey Zechstein Limestone is overlain by enormously thick, nearly pure white conglomerates (50 or 60 feet) of Bunter age: their constituent pebbles deserve rather the term "boulders," as some of them are so large, that they have to be blasted away before a sinking can be carried down to the coal. The rest of the Bunter consists of micaceous, dark-red, fine-grained sandstones with intercalated bands of clay. The Bunter series is generally found to increase in thickness as borings are carried northward: on the other hand, where the Upper Zechstein contains rock-salt, it in turn swells out to a thickness of hundreds of feet, as shown by sinkings near Wesel. At Schermbeck station, the Coal-measures are only reached at a depth of 2,920 feet from the surface.

The evidence obtained from the numerous borings put down throughout the region of the Lower Rhine leads the author to conclude that the

Bunter and Zechstein of that district are of the same age as, and practically continuous with, the Trias and Permian which form the north-eastern and eastern margins of the Cretaceous basin of Münster.

These Upper Cretaceous beds, as before mentioned, overlie unconformably and overlap the Bunter Sandstone, and then the Coal-measures. The lowest portion of the series in the Ruhr district consists of the Cenomanian or Tourtia glauconitic sands, with thick layers of clay-ironstone, and tough glauconitic marls. These are followed in upward succession by the Turonian light-grey or white hard marls, and these by the softer, more sandy Emscher Marls. In the neighbourhood of Recklingshausen the last-named are overlain by sandy marls of Senonian age.

It is noticeable that, as one proceeds eastward from the western margin of the basin, a gradual change in the lithological character of the Cretaceous deposits becomes manifest. While sandy beds predominate in the west, calcareous and argillaceous beds gradually assert their supremacy towards the east—in which direction the deeper sea must have lain.

In the east of the Ruhr basin, Glacial Drift immediately overlies the Cretaceous, but in the west, near the Rhine, Tertiary deposits intervene, attaining a thickness in the neighbourhood of Wesel of something like 1,000 feet. Going from south to north, the Coal-measures are found to lie deeper and deeper below the surface, and this change of level is very regular in the eastern portion of the basin; but in the western portion there is no such regularity, the drops in level being sudden and considerable. At all events, one point appears certain, that the farther northward borings are put down the deeper will the Coal-measures be found to lie.

With regard to water, the Bunter series is, of course, a great natural reservoir, and has been in that way a fruitful source of trouble in sinking. Some of this water, analysèd at Bochum, yielded a considerable proportion of common salt, and small amounts of magnesium-salts. Brine-springs occur in nearly all the underground workings of the pits south and south-west of Gladbeck, and undoubtedly come from the Triassic and Permian rocks, finding their way downward through the fault-fissures of the Coal-measures. Miners in the Ruhr coal-field will always have to reckon with the possibility of sudden and voluminous outbursts of water into the workings.

With regard to water in the Cretaceous rocks, the lowermost beds—the glauconitic Tourtia-waterbearing sands, act as a protective belt to the Coal-measures against further inflows of water from overlying beds. But where eastward the above-mentioned lithological change, from general "sandyness" to general "marlyness" takes place, water-bearing fissures make their appearance, so that the deep-level shafts of the Ruhr basin in sinking through the Cretaceous have had to contend with more or less voluminous inflows of water, being in some cases completely drowned. In the Cretaceous area of Münster numerous brine-springs well out from the hard, perpendicularly fissured Turonian marls. The neighbourhood of Hamm-an-der-Lippe is especially rich in such springs. The author describes some of these, and gives chemical analyses.

The Emscher Marls contain no brine-springs, and in fact form a water-tight compartment between the overlying Senonian and the underlying Turonian divisions of the Cretaceous, which are both waterlogged.

L. L. B.

IRON AND MANGANESE-ORES OF NIEDERTIEFENBACH, GERMANY.

Über die Entstehung der Mangan- und Eisenerzvorkommen bei Niedertiefenbach im Lahntal. By J. BELLINGER. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 237-241, *with* 5 *figures in the text.*

These deposits occur in rocks of Devonian age, between the *Stringocephalus*-limestone and the younger Schalstein (tuff). In form the ores vary from mere dendritic markings to huge shapeless nodules, and in composition from pure oxides of iron and manganese to excessively aluminated and silicated compounds. They may be regarded as the outcome of intense decomposition and weathering, continued even at the present day. The maximum thickness of ore-body mentioned by the author is 40 feet. A description is given of the series of chemical reactions by which the author conceives the ores to have been derived from the very rocks among which they now occur. L. L. B.

THE IRON-ORES, ETC., OF AMBERG, BAVARIA, GERMANY.

Die Amberger Erzlagerstätten. By ERNST KOHLER. *Geognostische Jahreshefte*, 1902 [1903], *vol. xv., pages* 11-56, *with* 10 *figures in the text.*

Mining operations have been carried on in the neighbourhood of Amberg, in the Upper Palatinate of Bavaria, for more than a thousand years, and at no period during that lapse of time have they been completely suspended. The most important deposits, both from the scientific and the industrial point of view, occur along three great fault-lines striking south-east and north-west through the district. Of less importance are the innumerable "nests" and pockets of brown ironstone, yellow ochre, etc., scattered all over the surface of the Jurassic plateau known as the Alb.

At Amberg, the ores occur in the form of irregular lenticles of brown hæmatite embedded in a mass of steeply-dipping sands and clays, which intervene between the Cretaceous and the highly-disturbed Jurassic strata. In depth, the entire ore-body is seen to increase in thickness, though in a somewhat irregular manner. In 1879, spathose iron-ore was for the first time discovered here; its structure is in part saccharoidal and crystalline, in part cavernous, and the ore is in fact not easily distinguishable by the eye from the dolomite against which it abuts and into which it sometimes passes. The geological conditions appear to be generally much the same farther north, at the Caroline and Etzmannsberg mines. In the last-named, the ore-deposit thickens from 100 feet at the 350 feet level, to 260 feet or more at the 367 feet level, where it can be followed for a length of more than 1,150 feet. It has been proved here that the ore-body is unconformable (geologically) both to its foot-wall and its hanging-wall. The brown hæmatite in this part of the field occasionally passes into red hæmatite.

As one goes south from Amberg, mine-exposures cease to be available, and the ore-deposits finally thin out at Paulsdorf and Altenricht. East of the Amberg fault-line is that of Vilseck-Auerbach, along which are found the mining concessions of Gross Schönbrunn and Minister-Falk, and the Leonie mine. Here again the ore-deposits are associated with the immediate proximity of Jurassic limestones and dolomites. Brown hæmatite has been proved at various depths from 52 to 321 feet, ranging in thickness from 20 to 65 feet; and between Bernreuth and Ritzelbuch, at a depth of 330 feet or so, spathose iron-ore has been struck, 60 feet thick. The borings

just mentioned were put down in the Minister-Falk field, where actual working has not yet been started. Interesting sections are figured of the Leonie mine at Auerbach, where the predominant ore is white to grey spathic iron-ore, while brown hæmatite plays only a subordinate part.

Along the third fault-line, which runs from Eschenfeld through Freihung to Kirchenthumbach, lead-ores occur (among sandstones and marls of probably Keuper age), which are not worked nowadays. The iron-ores also are found along the same line, always associated with Jurassic strata.

After a short description of the "nests" of ochre, etc., on the Jurassic plateau, the author proceeds to consider the question of the genesis of the ores. He concludes that they are unmistakably of metasomatic origin—that is, due to the gradual replacement of limestone by iron-compounds. These were derived from deep-seated thermal waters which welled up through the fault-fissures. These fissures were torn in the rocks in Tertiary times, and the not far-distant basaltic hills of Parkstein, Neustadt-am-Kulm, Oberleinleiter, etc., bear witness to the active vulcanicity of that period, to which the mineralized thermal waters are evidently assignable (post-volcanic phase).

Several chemical analyses are tabulated, the Amberg ores showing percentages of iron-sesquioxide which vary from 71·32 to 85·98.

The "nests" of ochre are regarded by the author as being in some cases, the decomposition-products of the limestones among which they lie. In other cases, they may be the remnants of ramifications of the great fissure-deposits.

L. L. B.

THE ORIGIN OF CERTAIN DEVONIAN HÆMATITES IN GERMANY.

Zur Frage nach der Entstehung gewisser Devonischer Rotheisenerzlagerstätten. By E. HARBORT. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie,* 1903, *vol. i., pages* 179-192, *and plates VIII. and IX.*

It is a fact of common knowledge that the Devonian hæmatite-deposits in north-western Germany almost invariably occur in the immediate neighbourhood of diabasic or schalstein-rocks; further, that they are richer, where these volcanic rocks are highly decomposed. Whence it was inferred that the iron had been exclusively derived from the decomposition-products of the weathered diabases; that it had been carried upward by carbonated solutions into the sedimentaries, and that most of the ore-deposits have been consequently formed by metasomatic replacement of the limestones, etc. But the fact that some hæmatite-specimens include fossils, wherein all the external structure of the organism is preserved in minute detail, is hardly reconcilable with the metasomatic theory; and Prof. Bergeat requested the author to examine various hæmatite-deposits, especially those of the Harz, in the light of this new objection.

He notes, in the first place, that the mass of weathered diabase necessary to supply the iron of hæmatite-deposits, many of which exceed 65 feet in thickness, is out of all proportion to any known occurrence of decomposed volcanic rocks in the regions traversed by him. Then, the stratigraphical evidence of itself condemns the metasomatic theory, as many thin layers of unaltered greenish-grey shale, or pure, compact, pale-grey limestones are in places interbanded with the hæmatites. Further, the hypothesis that the ore-deposits would impoverish in depth (because deeper down, below the general water-level of the country, the metasomatic replacement of the

sedimentaries would be impossible) has proved fallacious. Several deep borings in Nassau have recently struck workable ores far below that water-level.

The author concludes that these hæmatite-deposits are not secondary but primary formations; that they were laid down contemporaneously with the limestones and the tufaceous sediments; and that they must be regarded as belonging to the group of chemical precipitates. This is affirmed only of the Harz, as the author considers that he is not sufficiently acquainted with the hæmatite-deposits of Nassau, Westphalia and Bohemia, to dogmatize regarding them. Still, the hand-specimens, available in the Clausthal Museum, do not fit in with the metasomatic theory. The iron of the Harz hæmatites was doubtless derived in the first instance from the submarine volcanic eruptions of the Middle Devonian Period.

L. L. B.

THE MANGANESE ORE-DEPOSITS OF HESSE AND NASSAU, GERMANY.

Die Hessischen und Nassauischen Manganerzlagerstätten und ihre Entstehung durch Zersetzung des dolomitisirten Stringocephalenkalkes resp. Zechsteindolomits. By RUDOLF DELKESKAMP. *Zeitschrift für praktische Geologie,* **1901**, *vol. ix., pages* **356-365.**

The manganiferous and hæmatitic deposits of Hesse and Nassau almost invariably overlie either dolomitized *Stringocephalus*-limestone (Devonian) or decomposed Zechstein-dolomite (Permian), they in fact fill up the deep hollows in the uneven surface of these limestones. Moreover, the ores form irregular "nests" of varying size within these rocks, or occupy joints and fissures which cut deep into them. Generally a clay-bed overlies the ore-deposits: these, taken as a whole, form a mass 20 to 40 feet thick of manganiferous brown hæmatite, containing about 45 per cent. of iron and from 7 to 10 per cent. of manganese. Occasionally the main mass of the deposit is pure manganese-ore; or the manganese occurs in "nests" encrusted with brown hæmatite, or as lumps amid a pulverulent mass of the iron-ore. The ore-occurrences are spread over a very extensive area, but are of industrial importance at comparatively few localities. Their geological relationships being practically identical, it may be inferred that all these deposits originated in the same way.

The author describes briefly the mines in the Stromberg district, where a pulverulent mass of manganese-ore is worked, containing in its best parts lumps (up to the size of a man's head) of hard ore with 18 to 22 per cent. of manganese and 28 to 32 per cent. of iron. Proceeding then to the description of the deposits in the Odenwald, he points out that the pyrolusite and brown hæmatite in that area are unmistakably the decomposition-products of the underlying Zechstein-dolomite. The ore-deposits are conformably overlain by impermeable Bunter Marls, etc. The same evidence is forthcoming in north-western Spessart, where the ores occur within the Zechstein itself as well as on top of it, and in the lower portions of the ore-body perfectly fresh dolomitic sphærosiderite has been found. The most important deposit of all is that in the Lindner Mark, near Giessen, where the floor is dolomitized *Stringocephalus*-limestone: the more dolomitized and fissured this limestone is, the richer and more abundant are the ores. The deposit is overlain by clays which the author believes to be

in part of Pliocene age, and he controverts the hypotheses of Messrs. Ludwig and Volger who opined that these clays might be decomposition-residues of the dolomite. He discusses at some length the chemical processes connected with dolomitization, etc. The concluding portion of the paper is devoted to a short description of the ore-deposits of the Nauheim district. There, at the Oberrossbach mine, some of the finest manganese-ores in Germany have been obtained. The average percentages of the ores now worked in that district are 25 to 26 of manganese and 24 to 25 of iron. The best grades contain from 45 to 90 per cent. of manganese dioxide.

L. L. B.

THE MINERAL RESOURCES OF THE TAUNUS DISTRICT, NASSAU, GERMANY.

Die technisch nutzbaren Mineralien und Gesteine des Taunus und seiner nächsten Umgebung. By RUDOLF DELKESKAMP. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 265-276.

The Taunus range is rich in ore-occurrences, but in many cases these are so widely distributed through the mass of the rocks that the cost of mining operations and the difficulties of transport make the deposits unworkable. The mineral industry has only shown real vitality in the Lahn, Rhine and Wetterau districts.

Argentiferous galena and zinc-blende, generally associated (and with them copper-ores sometimes occur), are largely worked in the neighbourhood of Ems and Holzapfel in the Lahn valley. The infilling of the reefs consists of the above-mentioned ores with quartz, spathose iron-ore and iron-pyrites; they occur amid the clay-slates, quartzites and grauwackés of the Upper Coblentzian (Lower Devonian) series. Near the outcrops the sulphidic ores are, as in so many other cases, decomposed to oxides, carbonates, phosphates, etc. The ore-bodies sometimes appear to be stratified, and sometimes are amorphous masses, the maximum thickness being about 33 feet, although in one case it reaches double that measurement.

Iron-pyrites, slightly auriferous, is of widespread occurrence in the rocks of the Taunus, and this has given rise to many baseless rumours (as, recently, in the neighbourhood of Homburg) of gold being found there.

Iron-ores (red and brown hæmatite), generally manganiferous, and frequently associated with manganese-ores of excellent quality are worked all along the Lahn valley, from Diez to Giessen. The hæmatites vary greatly in texture, and the deposits vary equally in character—some being reefs, others being pockets or nests, and yet others being bedded. The "reefs" or "veins" generally yield brown hæmatite, and occur almost exclusively in the Taunus quartzites. Both iron- and manganese-ores appear to be genetically connected with the occurrence of quartz-veins.

The "beds" and "pockets" of brown hæmatite associated with the Lower Devonian sericite-schists contain from 41 to 47 per cent. of metallic iron; 2 to 2·6 per cent. of manganese; 1 to 2·5 per cent. of phosphorus; and 20 to 28 per cent. of residues (mostly silica).

Of far greater economic importance than the ores just described are the Middle and Upper Devonian red hæmatites. These extend over a considerable area, are interbedded among schalsteins and slates, and vary in thickness from 1 to 6½ feet. Some of the deposits are rendered unworkable because they contain too much lime, others because they contain too

much silica. One of the most considerable and interesting occurrences is that of Oberneisen, where the hæmatite appears in contact with the "Lahn porphyry": the best-grade ore here contains 65 per cent. of metallic iron. Then there are the iron and manganese-ores associated with the dolomitized *Stringocephalus*-limestone, the hummocky surface of which forms the floor or hanging-wall. These oft-described and much discussed deposits often penetrate deep into fissures and hollows of the underlying limestone, and are mantled by a barren cover of drift-sands and clays of varying thickness. The ore-bodies range in thickness from 20 to 40 feet, and lumps of pure psilomelane and pyrolusite are distributed through the crumbly hæmatite. It is noticeable that the more highly fissured and dolomitized the limestone is, the richer and more abundant are the ores. One of the most important mines that work these deposits is situated in the Lindner Mark, south of Giessen: the extensive workings here are opencast. Borings to the north and south have proved vast masses of still unworked ore of excellent quality.

Between Nauheim and Homburg-vor-der-Höhe are the manganese-mines of Oberrossbach and Köppern, where shafts have been put down to a depth of 213 feet, and workable ore still remains below this. The ore contains from 18 to 22 per cent. of manganese, 27 to 33 per cent. of iron, 0·3 to 0·4 per cent. of phosphorus, and 8 to 9 per cent. of residues. But it is much richer in manganese at the outcrop, and this holds good also (in regard to iron) of the accompanying brown hæmatite. A brief description of the not dissimilar ore-deposits of Weiler-West, Bingerbrück, Waldalgesheim, and the Bieberthal is also given, and the author then proceeds to consider the question of their origin. He regards many of them as primarily the result of weathering (decomposition of rocks by atmospheric agencies) but does not exclude the occasional intervention of ferruginous and manganiferous thermal springs; and he points out that the Nassau deposits (at all events) are generally regarded as having been formed by such springs and in no other way.

Brown coal is of frequent occurrence in the Tertiary deposits along the slopes of the Taunus; but in some places the quality, and in others the quantity, of the mineral is apparently not sufficient to justify working. However, about 118,000 tons of brown coal were got in the year 1900, the best being the Pliocene coals of the Friedberg district. The older (Oligocene) coals are much poorer. The quantity of workable brown coal still in sight is estimated at 15,000,000 tons.

Elaborate statistics are tabulated of the mineral output of the Wiesbaden and Koblenz districts and of the Grand Duchy of Hesse during the past six years. L. L. B.

THE MAGNETITE-DEPOSIT OF THE SCHWARZER KRUX, THURINGIA.

Das Magneteisenerzlager vom Schwarzen Krux bei Schmiedefeld im Thüringer Wald. By KARL SCHLEGEL. *Zeitschrift der Deutschen Geologischen Gesellschaft,* **1902**, *vol. liv., pages* **24-55**, *with* **3** *text-figures, and plates II. and III.*

The magnetite-deposits of the Schwarzer Krux, near Schmiedefeld, were worked for many centuries, and then abandoned in the latter half of the nineteenth century. Somewhere about 1888 an attempt was made to restart mining operations, but it was a purely spasmodic effort, and now the workings have fallen in: the enormous waste-heaps scattered through the forest alone bearing witness to the activity of former generations of miners.

A brief sketch is given of the literature of the subject, and the author

then describes the granite-massif on which the Schwarzer Krux is situated. This granite is presumed to date from Carboniferous times, while the sedimentaries through which it has torn its way are of Upper Cambrian age. The rock is of two varieties—typical biotite-granite and two-mica-granite: both varieties contain tourmaline. Quartz-porphyry dykes course through the granite-massif, and the granites themselves are full of inclusions of quartz-mica rock and hornblende-schist.

The waste-heaps really contain vast quantities of iron-ore which will be industrially available, so soon as the projected railway from Ilmenau to Schmiedefeld is completed. As in the case of the granites, etc., the author made an elaborate petrographical study of the magnetite, examining many scores of microscopic slides. The ore varies considerably in structure from compact, through finely granular, to coarsely crystalline: sometimes it shows traces of schistosity. Fluorspar is invariably associated with it: frequent associates also are wolframite, molybdenite, barytes and pyrites. An analysis of "magnetite-rock" yielded 88·55 per cent. of iron oxides and 9·10 per cent. of manganese oxide.

The ore occurs near the contact with the granite in the metamorphosed clay-slates, and apparently is itself really a metamorphosed hæmatite-deposit. Similar examples, due to contact-metamorphism, are cited from Spitzenberg in the Harz and Angers in the west of France. The fluorspar is no doubt the result of fluoric emanations which would make their way through the fissures in the rocks caused by the irruption of the granite. The occurrence of a garnet-rock rich in fragments of crystalline limestone also points to the former existence of limestone-bands in this locality. L. L. B.

THE ORE-DEPOSITS OF THE MÜSEN DISTRICT, GERMANY.

Der Schichtenaufbau des Müsener Bergbaudistriktes; die daselbst auftretenden Gänge und die Beziehungen derselben zu den wichtigsten Gesteinen und Schichtenstörungen. By MAX BRUCHER. *Verhandlungen des naturhistorischen Vereins der Preussischen Rheinlande, etc.*, 1902, *vol. lix., pages* 99-134, *with* 5 *text-figures and plates* II.-III.

The area in question comprizes various groups of high hill-ranges which form a portion of the Siegerland, and all the strata are of Lower Devonian age. They consist of an alternation of grauwackés, grauwacké-slates and clay-slates, all striking uniformly north-east and south-west, and dipping south-eastward at high angles (from 30° to 80°). The bedding is not especially massive, and stratigraphical units approaching or exceeding 160 feet in thickness are of rare occurrence. A detailed description is given of the highly-jointed grauwackés, and of the other strata already mentioned, but a group peculiar to the Müsen district is that of the Red Slates, interbanded at various horizons with the other rocks. They are very flaggy, splintery, and fairly hard (5 in the scale of hardness). Their brown-red coloration is doubtless due to the 10 per cent. or so of iron peroxide which they contain, and moreover that peroxide appears to be the material which has bound the other constituents of the slates together. Taken as a whole, the strata show signs of considerable disturbance and faulting, and the author describes at length the two main fissure-faults of the district: the Stuff and the St. Jakobskluft.

The ore-deposits are defined as independent lenticular veins, showing

great variations when compared one with the other. The author divides them into two categories:—(1) Ironstone-veins, the ore in which is mainly spathose iron and the gangue mainly quartz; and (2) ore-veins proper, containing sulphides of lead, zinc, silver and copper, with heavy-spar as the commonest gangue. At the outcrop, the metallic sulphides are frequently found decomposed to oxides and hydroxides. The veins in some cases represent the infilling of fissures which have been torn in the rocks without any intervention of lateral thrust. In other cases, they are the infilling of true fault-fissures, and in yet others they are genetically connected with overthrust-phenomena.

A short description is given of the most important ore-deposits. In the first place, as regards the iron-ores the Brücher vein, 10 feet thick, has been now worked out, and the same statement holds good of the Stahlberg deposit. The Sonnenberg, Kuhlenberg and Jungermann veins have been worked as far as it would pay, and are now abandoned.

Galena and zinc-blende are got from the Glücksanfang veins Nos. I. and II.; the ores apparently increase in richness and quantity the deeper down they are worked. Similar ores, with, in some cases, fahlores and copper-pyrites, are worked from about a dozen other veins. In the "diagonal vein" there are masses of pure ore 10 feet thick, and the entire ore-body is in places as much as 33 feet thick.

The ore-deposits are invariably cut off or nipped out by the Red Slates: these were in a relatively plastic condition at the time when fissures were being torn in the other rocks, so that fissures could not remain open in them to receive the metalliferous infilling. Later on the now Red Slates were infiltrated with the iron peroxide which has cemented them together. Generally speaking, there is cumulative evidence of a relationship between the fault-folds of the district and the metalliferous veins, as the number, thickness, and character of the latter have been unmistakably influenced by the former. It may be added that the sulphidic ores are very probably of more recent date than the iron-ores in the Müsen district.

L. L. B.

THE IRON-ORE DEPOSITS IN THE WESER HILLS, WESTPHALIA.

Die nutzbaren Eisensteinlagerstätten, insbesondere das Vorkommen von oolithischem Rotheisenstein, im Wesergebirge bei Minden. By DR. TH. WIESE. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 217-231, *with* 2 *figures in the text.*

At one time clay-ironstones alone were got in the Weser Hills, near Minden in Westphalia, but of late the winning of hæmatite has taken the front rank. It occurs in the Jurassic strata, in the neighbourhood of the famous *Porta Westphalica,* and the mines are connected by a light railway with the main line from Cologne to Minden. Clay-ironstones are still worked in the Wittekind seam, near Bergkirchen, and in the reniform concretions of the Bockshorn gravel-pit at Veltheim-on-the-Weser.

A description, geological and physiographical, of the Weser range of hills, based on Prof. Rœmer's and Dr. Heinrich Credner's monographs, is given by the author. It may be noted in passing that the Wittekind seam is a marly iron-pisolite in the Lower Kelloways rock, dipping near Bergkirchen some 30 to 40 degrees, 3 feet thick, overlain by a band of pyrites which in places is as much as 6¼ feet thick, and is in turn overlain by 8 inches more of pisolite. At Lutter, the pisolite is 6 feet thick. The ore contains, on an average, 30 per cent. of metallic iron.

Then follows a detailed description of the "seams" of red hæmatite which occur among the Upper Oxfordian limestones. At the Victoria mine, the lowest ore-band is called the Nammer-Klippen seam; it is oolitic in structure, and contains in its upper portion rather more than 22 per cent. of metallic iron: the total thickness of the seam varies between 33 and 40 feet. An interval of some 3 or 4 feet of blue limestone separates it from the next overlying seam, the Victoria, 6½ feet thick, containing about 40 per cent. (on an average) of metallic iron. Working was started on this seam in 1884, and it is now practically exhausted. Above this follows more blue limestone, 30 feet thick, and then the Joseph hæmatite-seam, in composition and appearance much like the Victoria seam. But, though analyses showed it to contain from 58 to 61½ per cent. of iron peroxide, it proved unworkable, as it thinned out so rapidly. The Lower Kimmeridge limestones and marls form the cover.

At Kleinenbremen, the following hæmatite-seams are recognized, in ascending order: (1) Nammer-Klippen seam, 13 feet thick, containing from 15 to 25 per cent. of metallic iron, as yet unworked; and (2) Wolverwahrt seam (with which among other minerals an anthracitic pyritous coal is associated), 4 feet or so thick, containing in choice samples 46 per cent. or more of metallic iron, and 0·11 per cent. of phosphorus, the average content of iron being from 38 to 40 per cent. This seam continues in depth to the west, but nips out in depth eastward.

The local designation of "seams" is, the author remarks, perhaps in fact hardly applicable to all of these hæmatite-deposits, although they are conformably interbedded with the strata among which they occur, and both as to roof and floor, sharply marked off from them. Microscopic examination shows that the minute structure of the deposits is truly oolitic, and they are in this and in other respects comparable with the Clinton ores. They were laid down in sea-water: so much is proved by the palæontological evidence. He concludes that they originated in the same fashion as the *minettes* or oolitic iron-ores of Luxemburg and Lorraine: iron-salts in solution, brought into the sea by springs or rivers, underwent a series of chemical reactions, the final result of which was the precipitation of the iron in the form of oxides and oxyhydrates. L. L. B.

THE BARYTES-DEPOSITS OF THE RÖSTEBERG, NORTHERN GERMANY.

Die Schwerspathvorkommen am Rösteberge und ihre Beziehung zum Spaltennetz der Oberharzer Erzgänge. By H. Everding. *Zeitschrift für praktische Geologie*, **1903**, *vol. xi., pages* **89-106**, *with* 11 *figures in the text.*

The Rösteberg (1,175 feet above sea-level) is the highest summit of a ridge which marks the boundary between the Palæozoic massif of the Harz mountains and the Mesozoic foot-hills, in the district that lies between Grund and Gittelde. The barytes occurs in apparently-bedded deposits of Permian age forming the very top of the Rösteberg; and a hundred feet or so away, in the Palæozoic slates is the old Hülfe Gottes (God's Help) metalliferous mine, which was worked for many generations. The remarkable occurrence of the Rösteberg crops up again and again in the scientific literature dealing with the Harz, a short summary of which is given. After a fairly-detailed description of the barytes-deposits as seen in several small

quarries opened up to work it, the author proceeds to consider the vexed question of its origin. All the evidence that he can adduce points to its genesis through metasomatic replacement of the Zechstein Limestone, brought about by the active circulation of thermal waters carrying barium, etc., in solution.

It has been shown that pure barytes is being formed in certain Westphalian collieries at the present day, by the interaction of pit-waters, some containing barium salts and the others sulphates in solution, and this is in localities where the Carboniferous is much disturbed by cross-faulting. The Rösteberg mineral is in truth genetically connected with the fault-fissures, some of which in the immediate neighbourhood were infilled with metalliferous ores; and this faulting probably originated at the same time and from the same causes, both within and without the orographic boundary of the Harz massif. But the Rösteberg faults are at any rate post-Permian, since the Permian strata have been disturbed by them; therefore, too, all the metalliferous veins of the Upper Harz are post-Permian (including the God's Help vein). The long process of mountain-building, in the case of the Harz, may well have lasted from the close of the Devonian into Tertiary times. Whether the metalliferous veins occupy fissures first formed during the latest movements, or whether these fissures really date back to the earlier movements, and were continued and re-opened by the later, is a point still in dispute. L. L. B.

ORIGIN OF THE PYRITES-DEPOSITS OF RAMMELSBERG, GERMANY.

Ueber merkwürdige Einschlüsse im Kieslager des Rammelsbergs bei Goslar. By ALFRED BERGEAT. *Zeitschrift für praktische Geologie,* **1902,** *vol. x., pages* **289-293,** *with* **2** *figures in the text.*

In contradistinction to Prof. Vogt's view that the Rammelsberg ore-body is of the nature of a vein-deposit, the author holds that it cannot possibly be anything else than a true bedded deposit, which was formed contemporaneously with the Wissenbach slates and is a member of that series of strata. In support of this opinion he adduces fresh evidence in the shape of masses of iron-pyrites, smooth and reniform, which occur amid the so-called "mixed ore" (alternating bands of fine grained chalcopyrite and galena) of Rammelsberg; these are unmistakably concretions formed within a sedimentary bed, and would of themselves be sufficient to dispel the notion (if it were otherwise admissible) that the pyrites-deposits near Goslar were the outcome of the metasomatic replacement of limestone. L. L. B.

PRECIOUS OPAL OF DILLENBURG, GERMANY.

Opal in der Gegend von Dillenburg. By — LÖCKE. *Zeitschrift für praktische Geologie,* **1903,** *vol. xi., page* **303.**

The author recently discovered precious opal in a freshly opened exposure of eruptive diabase on the right bank of the Irrschelde valley, 2½ miles north-east of the village of Oberscheld, in the district of Dillenburg (Nassau).

The mineral occurs in bluish to milk-white lumps, varying in size from that of a hazelnut to that of a walnut, in small "nests" in the diabase, sometimes intergrown with red hæmatite. The opal showed conchoidal fracture and (in places) most brilliant iridescence.

In some cases crystalline quartz was associated with it. L. L. B.

THE NICKEL-ORES OF SOHLAND, SAXONY.

Ueber eine neue Nickelerzlagerstätte in Sachsen. By DR. R. BECK. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 379-381.

The author recently announced the discovery of nickel-ore deposits in the neighbourhood of Sohland, district of Lausitz. Meanwhile, exploration-work has proceeded apace, yielding new information as to the geological conditions of the occurrence. A dyke of igneous rock, defined by the author as an olivine-proterobase rich in biotite, some 33 feet thick, strikes west-north-westward through the Lausitz granite, and its northern salband has been traced for about 2,300 feet. The ore occurs at the junction of the proterobase and the granite, dying out into either rock into a mere impregnation, and then disappearing altogether. At the bottom of the Herberg exploration-shaft, the ore-band attains thicknesses of 5 to 8 feet, but it dwindles towards the outcrop to a few inches. Where the igneous rock is least decomposed the ore is mainly (nickeliferous) magnetic pyrites; nearer the surface, in proportion as the igneous rock is more decomposed and broken up into spheroids, copper-pyrites, and then malachite and limonite make their appearance, forming often the cementing-material of the spheroids of semi-decomposed igneous rock.

In the richest parts, the percentage of nickel varies between 4 and 5, in association with 2 per cent. of copper. This compares favourably with Canadian ores of a similar character. So far, a depth of only 35 feet below the surface appears to have been reached, but it is believed that the ore goes down to at least double that depth. A second shaft has been sunk close to the Saxon frontier, and the indications are promising, although the granite-junction has not yet been struck. L. L. B.

PHOSPHORITE-DEPOSITS OF THE VOGTLAND, SAXONY.

Die Phosphoritführung des Vogtländischen Obersilur und die Verbreitung des Phosphorits im Altpalæozoicum Europas. By L. KRUFT. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1902, *XV. Beilage-band*, *pages* 1-65, *and plates I.-II.*

The three groups into which the Upper Silurian of the Vogtland is divisible, namely the Alum-shales, the Ochreous Limestone, and the Siliceous Shales, are all known to contain phosphates in a finely divided state; but the Siliceous Shales, and more especially the Alum-shales, are characterized by the occurrence (in places very abundantly) of phosphorite-nodules.

The nodules vary greatly in size and shape; they are black when freshly extracted from the matrix, but weather ultimately to a light-grey. Sometimes they coalesce into slabs of reniform concretions some 2 inches thick, and they are invariably tough and difficult to smash up.

The author made a series of careful chemical analyses, which yielded (in the case of the Leuchtsmühle, Plauen and Pöhl phosphorites) about 37 per cent. of phosphoric acid and from 25 to 45 per cent. of lime, the other principal constituents being silica, alumina, magnesia and iron. Traces of iodine were detected in most instances, and fluorine in one. The average specific gravity of the mineral is 3·01.

The nuclei of many of the nodules consist of fossil organisms (crustacea, graptolites, cephalopoda, radiolaria, etc.), the hard portions of which have been converted into phosphorite. Where the shales contain these nodules

they are no longer phosphatic; but, as above-hinted, the shales are distinctly phosphatic where the phosphorite-nodules do not occur. This gives a clue to the genesis of the deposits. The organisms decomposing amid the mud of the Silurian sea-floor gave rise to an evolution of carbonic acid, which dissolved out the phosphate of lime whereof their endo- or exo-skeletons were partly made up; this phosphate was replaced by the less easily-soluble phosphate of lime from the sea-water, which tended gradually to accrete around such organic nuclei in the from of an ever-thickening crust or nodule. From the algæ in the sea-water the omnipresent iodine was evidently derived.

The author points out that similar phosphorites occur in the Upper Silurian of neighbouring districts, and he gives a brief description of all such occurrences in the older Palæozoic of Europe generally, from the Lower Cambrian to the Upper Devonian inclusive. No information is to be gleaned from the paper as to the working (actual or prospective) of the Vogtland and other deposits. L. L. B.

GENESIS OF THE ORE-DEPOSITS OF UPPER SILESIA.

Zur Genese der Oberschlesischen Erzlagerstätten. *By* G. GÜRICH. *Zeitschrift für praktische Geologie*, 1903, *vol. xi.*, *pages* 202-205, *with* 1 *figure in the text.*

From a recent study of the "main ore-body" or lower horizon in the Beuthen basin, the maximum thickness of which is 40 feet, the autnor arrives at the conclusion that the same causes as those which brought about the dolomitization of the limestone country-rock also brought about the deposition of the ores themselves (galena, marcasite, zinc-blende and calamine). He considers that all these were present in solution in the Triassic Sea, not that they welled up through the fault-fissures in the rocks. The dolomite and the associated ores occur not only in the Beuthen basin, but to the south-east in Galicia (Trzebinia and Krzeszowice), and to the north-east in the Tarnowitz basin, stretching thence into Poland. Fault-fissures, it is true, are not wanting over this vast extent of country, but there is an equally faulted region of Muschelkalk to the west, without a trace of dolomitization or ore-deposition. L. L. B.

COBALT-ORES IN THE THÜRINGERWALD, GERMANY.

Neue Kobaltaufschlüsse im Thüringerwalde. *By* P. KRUSCH. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 1902, *vol. liv.*, *Protokolle*, *pages* 55-58.

The most important cobaltiferous veins in the Thuringian Forest are those of Schweina-Glücksbrunn, described in detail by Dr. Beyschlag.* They form the infilling of fault-fissures in the Zechstein series, and the metalliferous impregnation extends upward into the limestones as well as downward into the conglomerates of that series. The thickness of the veins is extremely variable, but the richest are generally those of medium thickness. Mining industry, which had been active in the district ever since 1720, was brought to a standstill in 1850, because means were not then available for carrying on deep-level workings. Within recent years, however, there has been a revival, and a new cobaltiferous vein has been struck. This, the so-called Beyschlag reef, carries smaltine with a gangue of heavy-spar, and ranges in thickness from a few inches to 5¼ feet. A percentage analysis of the ore yielded the following result: Cobalt 10·93,

* *Zeitschrift für praktische Geologie*, 1898, *vol. vi.*, *page* 1.

nickel, 6·12, arsenic 75·04, iron 5·22, copper 0·31, and sulphur 1·61, corresponding to the formula $Co(Ni)_2As_5$. Attention is drawn to the high percentages of nickel and arsenic.

The discovery is of considerable importance for the German colour-manufacturers, as most other cobalt-ore deposits in Germany have been worked out, and manufacturers have been perforce dependent on imports of foreign ores.

Meanwhile exploration-work is going on in the neighbourhood of Königsee, where highly-fractured masses of Zechstein are faulted down against the Cambrian formation. The decomposed relics of cobaltiferous veins have been found, but search is directed to unaltered deposits, and the author seems to view the prospect as hopeful. L. L. B.

THE POTASSIUM SALTS OF GERMANY.

The Potassium Salts Industry of Germany. By E. MACKAY-HERIOT. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii.*, *pages* 462-463.

The discovery of natural potassium salts in large quantities in Germany has given rise to a new and flourishing industry. The laws of ownership vary in the different states: in Old Prussia, the salts belong to the man who first demonstrates a payable deposit to the Government; in Hanover, they belong to the landowner; whilst in Brunswick and other States they are a Government monopoly.

Several theories of the origin of these large salt-areas have been framed, but modern theory teaches that the salts were originally precipitated from sea-water. It is unlikely that they resulted from other salt-formations after these had been dissolved, because the foot-wall is generally anhydrite and limestone, which can hardly have been explained except by assuming the ocean as the source. But the great depth of the North German salt-areas points to the conclusion that one filling of a basin could not have been responsible for such immense deposits, and the ocean cannot therefore be taken as the direct origin. It is much more likely to have been an inland sea either temporarily disconnected from the ocean by a bar, or the bar would let just as much salt-water pass through as could be evaporated by the tropical heat of the Upper Permian era. In the first case, the bar would be closed either by raising or sinking actions, or by heaping up of masses, such as sand. All these obstructions might in time be washed away, and thus permit a new filling of the sea-basin. This process could often be repeated.

The North German salt-deposits may be classified into two types as regards occurrence. The Stassfurt type is marked by its regularity of occurrence, and has but one layer of potassium salts. The Hanover type differs from the Stassfurt type in that several layers or nests of potassium salt are found, and often differing from each other in composition. All the paying deposits of these salts in Germany have been found in the Upper Permian formation. X. Y. Z.

BORINGS FOR SALT IN BADEN, GERMANY.

Die Tiefbohrungen auf Steinsalz in Baden im Vergleich mit denen in Franken. By DR. OTTO M. REIS. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 187-190.

Borings put down near Dürrheim, in the Grand Duchy of Baden, have shown that the thickness of the Middle Muschelkalk in that neighbourhood

averages 280 feet. This formation contains rock-salt, anhydrite and gypsum-deposits, both in Würtemberg and Bavaria, as well as in Baden; and the author's main purpose is to correlate the salt-bearing strata in those three States of the German Empire.

The main anhydrite-bed (with salt-impregnations) at Dürrheim has an average thickness of 82 feet. The corresponding bed is much thicker in Franconia, but there contains no salt. In both regions, however, the important (true) salt-bearing stratum is found much lower down: it is capped by a band of anhydrite (thinner in Baden than in Franconia), and including clay-partings, etc., attains a thickness of about 100 feet. A clay-and-anhydrite parting about 20 inches thick is so continuous over the entire area, being proved at Heilbronn as well as at Dürrheim, that it is held to represent a widespread geological episode; possibly the after-effects of an interruption of the sequence of deposition by the inflow of sea-water or fresh water. The rock-salt above this parting diminishes in thickness and purity from Dürrheim eastward; indeed for some distance north-east of Schwenningen, the borings put down failed to strike salt at all. L. L. B.

BORINGS FOR ROCK-SALT IN BRUNSWICK AND HANOVER.

(1) *Ueber die Bohrungen auf Kalisalze im Norden der Stadt Braunschweig; and*
(2) *Ueber die Ergebnisse einer Bohrung auf Kalisalze bei Vorie an der Bahn Hannover-Altenbeken. By* J. KLOOS. *Zwölfter Jahresbericht des Vereins für Naturwissenschaft zu Braunschweig,* 1902, *pages* 60-67.

Both these papers emphasize the unhappy results of speculative borings, undertaken in defiance of the geological probabilities which can be postulated from the careful study of the tectonics of any given area. In the Province of Hanover, boring for rock-salt was at first confined to those districts where the Bunter Sandstone overlies the salt-bearing Zechstein. As these districts became completely parcelled out among concessionaires, speculators turned their attention to areas where the Bunter Sandstone is replaced by the next later formations, Muschelkalk and Keuper. From that moment all regard for scientific methods of procedure was cast to the winds, and borings were put down on the rash assumption that where one series of strata was exceptionally thick, the next underlying would have proportionately thinned out, and that consequently the salt-bearing beds would always be struck at somewhere about the same depth! [So much for the marvellous German "efficiency" which is constantly being dinned into British ears at the present day.] Soon the borings were extended even to districts of the North German plain where the Keuper is absent, and the Cretaceous immediately underlies the Tertiary and Drift-deposits: in a few isolated instances these were successful. Many, on the other hand, were stopped in barren strata at depths of 1,600 and 1,900 feet.

The author describes the Cretaceous and Jurassic fossils obtained from the boring-cores, and lays stress on the scientific interest of the borings, which is, of course, unaffected by their failure from the industrial point of view.

L. L. B.

THE MINERAL WEALTH OF THE GERMAN COLONIES.

Die nutzbaren Bodenschätze der Deutschen Schutzgebiete. By A. Macco. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 28-33 *and* 193-202, *with a map in the text.*

Northern Togoland.—A hill, which rises nearly 800 feet from the plain, north-west of Bányeri, consists almost entirely of massive hæmatite, seamed by quartz-veins. Analysis shows 98·43 per cent. of iron peroxide, 1·54 of silica, and 0·03 of phosphorus pentoxide. Whole hills of hæmatite are also reported to exist at Kabu and Bássari.

Central Togoland.—Lenticles of red hæmatite interbedded with the quartzites of the Santrokofi-Akpafu range yield on analysis 78·4 per cent. of iron peroxide, 10·5 per cent. of silica, 0·73 of phosphorus pentoxide, and 9·98 of water.

Kameroons.—Gold is reported from the neighbourhood of the Edea falls, and in Aboland gold and silver have been found in very small quantities. Limonite is of widespread occurrence in lateritic deposits, and copper-ore has been reported from Baliland. An expedition has been sent out to study the German territory in the Benué region from the economic point of view. Tin-ore certainly occurs in that area, but how and where the natives work it is as yet unknown. Native sulphur, the product of a still active *solfatara*, is found in considerable quantity on the northern slopes of the Kameroon range.

German South-west Africa.—Important finds of native gold are recorded from the river-beds in a few localities, but gold *in situ* is always associated in that region with other ores. For example, with bismuth at several points along the lower course of the Kuisib river, and near Gaogos; with copper along the course of the Swakop. At Potmine only, on the last-named river, has an adit been driven to some depth, when the deposit was found to become completely barren of gold. The surface-indications in the Rehoboth district awakened great hopes in the early eighties. These have not been fulfilled so far, but enhanced facilities of transport (when the railway replaces the ox-waggon), and the provision of a fair amount of capital, may make it possible to work certain gold-reefs there at a profit. The gold occurs in quartz-veins seaming the mica-schists, and is associated with copper-ores. The percentage of gold varies from 3 to 20 parts in a million, and of silver from 20 to 362 parts. Pure copper-ores without a trace of gold, occur at Angra Pequeña, Aos, etc. At Gorup, the ores are both auriferous and argentiferous. Much exploration and prospecting-work has been done, but mining operations have not been seriously started as yet, at the so-called Hope mine, south-east of Walfisch Bay. At the Matchless mine, 105 miles east of Gorup, the now dormant mineral-industry may well be quickened into life again when the projected railways are built.

In the Otavi district there is a great spread of limestones wherein copper-glance and galena occur in apparently payable quantities. Magnetite-deposits have been noted in the gneiss of Angra Pequeña, Ugama, Aos, etc.

The famous diamond-bearing "blue ground" stretches from British into German territory, where typical ocurrences of it have been noted in four localities. Coal has not yet been struck, and such graphite as occurs would not repay working.

Marble of promising quality, and of all hues varying from pure white to deep black, is found at several localities in the immediate neighbourhood of the Swakopmund and Windhoek Railway.

German East Africa.—The Colonial Administration has reserved to itself

the right of working or leasing the gold-placers which undoubtedly exist along some of the watercourses. Some leases were granted about the end of 1902, covering a number of streams which flow into the Victoria Nyanza. Gold-reefs occur on the Iramba plateau, but one gathers that they would hardly repay working under present conditions. The same statement appears to apply to the copper, lead and iron-ores reported from various localities. Coal occurs in the Karoo Beds on the shores of Lake Nyassa, but not in the workable seams on the eastern shore; while on the north-western shore, on the right bank of the Kiwira, there is a bottom seam 16 feet thick, two seams 16 feet thick, two seams rather more than 6½ feet thick, and one 5 feet thick. The coal-formation crops out here for a distance of more than 9 miles, strikes north and south, and dips gently eastward. As one approaches the British border the seams appear to thin out. Three qualities of coal are distinguishable: a lustrous, graphite-like, specifically light, non-stratified mineral; a compactly-bedded, heavy, bituminous mineral; and a shaly, generally light, but sometimes pyritous coal. The first-named usually forms the thickest part of the lowermost seam; the bituminous coal has been struck in four different seams at various horizons, and alternates with the third variety in quite a number of other seams. Samples have only been taken so far from the outcrops, and so it is not surprising to learn that the percentage of ash is rather high, The heating-power of the bituminous coal alone is stated to exceed 6,500 calories.

Workable deposits of mica occur in the Uluguru range, and garnets, with a tinge of bluish-red and extraordinarily high refractive power, are found among the weathered hornblende-gneisses of the Namaputa district.

Sub-fossil gum-copal is found in considerable quantities in sandy soil in the coast-districts.

Kaiser Wilhelms-Land [*Pacific Ocean*].—Besides gold-placers, platinum-bearing basalts and coal have been proved. In the Palau and Marschall Islands are vast deposits of phosphates.

China.—The author winds up the tale of the German colonies with a sketch of the mineral resources of Shantung, modestly regarded as the *hinterland* of Kiaochau. On October 30th, 1902, the first railway-train loaded with the coal worked by a German syndicate at Weihsien, entered Tsingtau station. The quality of the mineral is about midway between good Westphalian and the best Japanese coal, and it has given satisfactory results when tried on board the German squadron. The greatest coal-field in the province appears to be that of Poshan-Puki-Putsun (170 miles distant from Tsingtau). The coal-basins of Heishan and Hsiho, south and east of Poshan, have been completely worked out by the Chinese. The Laiwu coal-field lies in a mountain-district apparently difficult of access. Along the Hsiau-wönnho valley is a 20 miles belt of Coal-measures, with a seam of good bituminous coal, 6½ feet thick. Brief references are devoted to the coal-occurrences of Ichaufu, Tsau-chuang and Küchau.

L. L. B.

BROWN COAL IN GREECE.

(1) *Neue Braunkohlen in Griechenland; and*

(2) *Ueber einen Retinit in Thessalien. By* C. ZENGELIS. *Tschermak's Mineralogische und Petrographische Mittheilungen, n.s., vol. xx.* (1901) *pages* 355-356.

The most important of the coal-deposits recently discovered in Hellenic territory are those of Thessaly, Halonesos and Kumi. The Thessalian

mineral is hard, brittle, pitch-black, lustrous, and easily combustible. It has a specific gravity of 1·302, and its conchoidal fracture is so well-marked as to place it alongside jet. The other coals are, properly speaking, lignites, dark-brown, fibrous, and fairly tough. The Kumi lignite is now being successfully used for producing generator-gas to heat the retorts of a sulphur-refinery in the neighbourhood of Athens. Chemical analyses of the coals and lignites yielded the following results:—

	Bituminous Coals from Thessaly.				Brown Coals or Lignites from			
					Kumi.		Haloneso.	
	Dried in Air.		Dried at 221° to 230° Fahr.		Dried in Air.	Dried at 221° to 230° Fahr.	Dried in Air.	Dried at 221° to 230° Fahr.
	A.	B.	A.	B.				
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hygroscopic water ..	8·27	12·00	—	—	10·03	—	10·51	—
Carbon	68·00	65·40	73·97	73·91	48·86	54·06	53·84	60·16
Hydrogen	3·82	3·64	4·16	4·14	4·24	4·72	3·52	3·92
Nitrogen	0·82	0·77	0·89	0·87	0·65	0·72	0·65	0·72
Sulphur	2·30	2·17	2·48	2·46	2·07	2·30	1·75	1·95
Ash	2·45	·2·35	2·69	2·67	10·40	11·55	4·19	4·67
Coke	62·53	59·62	68·19	67·75	53·87	59·85	53·00	59·21
Calorific power:—			Calories.	Calories.		Calories.		Calories.
Calculated ..	—	—	6,672	6,660	—	4,615	—	5,637
Determined ..	—	—	7,112	7,097	—	5,383	—	5,902

Following upon the discovery of the coal in Thessaly in 1900, a variety of the mineral retinite was found in the same province, near the village of Vlachokastania. It is yellowish-red, almost completely opaque, hard, and tough, with a specific gravity of 1·0023. It is easily ignited, and burns well, with a smell of burning amber. At temperatures above 528° Fahr., it begins to melt and to decompose. Chemical analysis showed that it contains 78·47 per cent. of carbon, 9·23 of hydrogen, 10·6 of oxygen, and 0·39 of sulphur. Its calorific power is estimated at 9,056 calories. It yields 1·47 per cent. of ash, and from it by solution in turpentine-oil a good adhesive varnish can be made. The chemical formula to which it most nearly approaches is $C_{10}H_{14}O$, which is that of many ethereal oils and resins.

L. L. B.

THE COAL-FIELD OF DUTCH LIMBURG.

Le Bassin Houiller du Limbourg Hollandais. By A. HABETS. *Annuaire de l'Association des Ingénieurs sortis de l'École de Liége*, **1901**, *series* **5**, *vol. xiv., pages* **233-263**, *and* **2** *plates*.

This paper begins with a brief history of the recently-revived coal-industry of Dutch Limburg; and we learn that, as far back as 1113, the Abbots of Rolduc possessed coal-workings on the banks of the Worm. Of late years, considerable extension of the field in a north-westerly and northerly direction has been proved by boring, and by an Act of the Dutch Legislature of July 12th, 1901, the State has reserved for its own use an area of about 36,000 acres. Certain other areas already conceded are, moreover, to revert to the State in 1945.

The author publishes on a reduced scale a copy of the section and map drawn by Mr. C. Blankevoort, the engineer who superintended the borings on behalf of the Government of the Netherlands. These borings, to the number

of 70, are spread over an area of about 78 square miles, and the evidence at present available is, therefore, not quite sufficient to admit of an exact section of the coal-field. There are doubtless many more irregularities and disturbances than can be pictured from the data supplied, and the author points out that it is not often in this area that the seams proved in one boring can be absolutely correlated with those proved in the next.

He gives in an appendix details of the 70 aforesaid borings, about a dozen of which failed to strike the coal, and he considers that the only classification of the seams that is possible at present is one based on chemical analysis. Just as in the coal-fields of Westphalia and Aix-la-Chapelle, the coals may be grouped from top to bottom of the series according to the decreasing proportion of their volatile constituents. In this way he plots out a map, showing that the highest belt of coal ranges along the northern boundary of the field (gas-coal with 30 per cent. of volatile matter). He recognizes the existence of a fault forming the eastern boundary, running in the same direction as the Feldbiss fault, which has been traced for several miles in the Aix-la-Chapelle basin, separating the anthracitic seams of the Worm district from the bituminous seams of the Alsdorf district. He does not altogether concur with Mr. Blankevoort's mapping of the boundaries and fault-lines, and gives in detail the reasons for differing from that engineer. L. L. B.

ANTIMONY-ORES OF CETINE DI COTORNIANO, TUSCANY.

Cenni sui Minerali della Miniera di Antimonio delle Cetine di Cotorniano. By G. D'Achiardi. *Atti della Società Toscana di Scienze Naturali, Processi Verbali,* 1901, *vol. xii., pages* 232-236, *with* 1 *figure in the text.*

The antimony-mine of Cetine di Cotorniano, in the province of Siena, was worked for the first time in 1878. The deposit is a few hundred feet away from the high road betwen Siena and Massa Marittima, a little beyond the gorge which near Rosia cuts through the Montagnola Senese. It consists of a band of chalcedonic quartz and stibine at the junction between the Permian sandstones and the Rhætic limestones (thought by Mr. B. Lotti to be possibly Eocene). The last-named become visibly more siliceous as the junction is approached: whence it may be inferred that quartziferous and antimoniferous thermal springs, flowing up through the sandstones without altering them, in part dissolved away the limestone, the present ore-deposit being thus metasomatic in character. The stibine is distributed in it very irregularly, there being some points where the ore is concentrated in rich masses, and others where there is scarcely a trace of ore. The strike is nearly due east and west, and the mass is split by fissures running north and south, containing red oxysulphide and white oxide of antimony. In some places the quartz is cavernous, and impregnated with much native sulphur.

Detailed descriptions, from the mineralogical and crystallographic point of view, are given of the stibine, stibiconite or antimony-ochre, cervantite, chermesite, sulphur, quartz, calcite, and gypsum found here.

L. L. B.

ANTIMONY-ORES OF CAMPIGLIA SOANA, PIEDMONT.

Il Giacimento Antimonifero di Campiglia Soana nel Circondario d'Ivrea. By V. NOVARESE. *Bollettino del Reale Comitato geologico d'Italia*, 1902, *vol. xxxiii., pages* 319-332.

At the head of the valley of Soana di Campiglia, in the district of Ivrea, the observer's attention is attracted by some "raddled" rocks, which are in truth the limonitic gossan of an ore-deposit, consisting of sulph-antimonites of lead, iron, copper and silver. The mineral-outcrop runs for about 1¼ miles parallel with the stratification of the finely-schistose gneisses among which it occurs, north—60° to 70°—west. These fine gneisses appear to be a local intercalation among the cyclopean masses of the porphyroid-gneiss of the Gran Paradiso. The ore-body really consists of several groups of quartz-reefs, superposed at intervals through a thickness of about 1,000 feet of gneiss. The exploration-work so far accomplished is small, in comparison with the extent of the deposit; but the precipitous nature of the crags among which the ore-body occurs, and the formidable screes under which it lies buried on the gentler slopes combine to make such work very difficult.

At one time stibine was thought to be the chief antimony-ore present: in reality it occurs only in very small quantities, and it would appear that what was mistaken for it is a ferriferous variety of jamesonite. This is a steel-grey, highly-fibrous mineral of specific gravity 5·48, and hardness 2 to 3. Analysis shows it to contain 34·22 per cent. of antimony, 40·21 per cent. of lead, 3·62 per cent. of iron, 21·27 per cent. of sulphur, and minute proportions of copper, silver and gold. The author enters into an elaborate comparison and study of the analyses, appearing rather to favour the hypothesis that the mineral consists of a combination of 5 molecules of berthierite with 3 molecules of boulangerite, expressed by the following chemical formula:—$5(Fe\,Sb_2\,S_4)\,3(Pb_5\,Sb_4\,S_{11})$. Intimately associated with it is a fahlore, brittle, of a bright grey when fresh, yellowish or iridescent when altered by atmospheric agencies, of a hardness greater than 3. It is a tetrahedrite conspicuously rich in silver, and analysis has also shown it to contain copper, but no lead. Pyrites occurs in lenticles, always clearly separable from, and never mixed with, the sulph-antimonites; and the presence of galena is traceable among the old waste-heaps. The deposit is said to have been first discovered about 1869, but it may well have been worked for silver in ancient times, of which there is now no record. L. L. B.

THE ASPHALT-DEPOSITS OF RAGUSA, SICILY.

Über das Asphaltvorkommen von Ragusa (Sizilien) und seine wirthschaftliche Bedeutung. By DR. H. LOTZ. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 257-265, *with 5 figures in the text.*

The "compressed asphalt" from Ragusa has given especially good results when used as a paving-material in Germany, so much so that municipal contracts in that country are let out in most cases with the express stipulation that Sicilian material shall be used. It is currently termed "asphalt," but, as a matter of fact, it is a bituminous limestone. In this paper, the author adopts the current phraseology for simplicity's sake, and restricts the term "bitumen" to sundry complex constituents which are soluble in carbon-bisulphide.

Ragusa, a town of some 30,000 inhabitants, is situated on a high plateau

of Miocene limestone, in the province of Syracuse, in the south-eastern angle of the island. The plateau is cut off by a fault, with a downthrow of many hundred feet, from the fertile plains of Vittoria and Comiso (made up of Pliocene deposits) on the west and from the plain of Catania on the north-east; but the Miocene limestones and marls slope gradually to the south-east. Basalts and volcanic tuffs, connected with the Pliocene deposits, occur along the fault-line, rising in Monte Lauro to a height of 3,034 feet above sea-level.

The pure-white Lower and Middle Miocene limestones, with marly intercalations and siliceous lenticles, are at least 1,800 or 1,900 feet thick; while the sulphur- and gypsum-bearing Upper Miocene is all but entirely absent from this part of Sicily. The limestones (including the asphalt) are sparsely fossiliferous, but evidently of marine origin. The asphalt-quarries extend for 1½ miles along the upper margin of the Val Ermineo, and also occupy a narrow belt on the rim of the plateau itself towards the east. The asphalt-outcrops are not easily recognizable at first sight, as the mineral on exposure to the air is quickly encrusted with a thin white film, and thus looks exactly like the associated limestone. This weathered surface-mineral is locally termed *albame*, the less weathered (containing from 7 to 8 per cent. of bitumen) *gerbina*, while the better quality (of real commercial value) contains 10 to 18 per cent. of bitumen, and varies in colour from chocolate-brown to nearly black. The deposits vary greatly in quality and in the amount of barren limestone-cover from quarry to quarry. In some cases, they are worked opencast: in others, it is found necessary to drive adits some distance into the hillside. Still, it has been proved that the asphalt does not extend westward far into the plateau—the "linear" extension of the occurrence is one of its main characteristics, and throws some light on its origin. "Horses" of limestone are frequently found in the midst of the richest asphalt, and sometimes beds of asphalt and limestone alternate repeatedly. The rocks are much fissured and shattered, but there is no certain evidence of considerable overthrust.

Rejecting Prof. Coquand's views in regard to the genesis of the Ragusa asphalt, the author holds that, like other bituminous deposits described by Messrs. Malo and Delano, it is the result of the sublimation or upward percolation through fissures of gaseous or liquid hydrocarbons. These were probably derived from the decomposition of organic remains, vegetable or animal, perhaps more likely the former. The impregnation of the limestones with this bitumen is supposed to have taken place in Pliocene times.

The asphalt-industry is of the greater importance for Sicily that sulphur-mining there is in a moribund condition. The new industry employs at present 1,000 workpeople. The mines owe to their high situation freedom from the fevers of the lowlands; but, although work goes on summer and winter alike, the innumerable saints' days and holidays bring the number of actual working-days in the year down to 180. In 1901, the production of asphalt amounted to 75,270 tons, and of bituminous limestone (used locally for building purposes) to 4,100 tons. The output has increased enormously within the last 10 years, but on the other hand prices have fallen by 33 per cent. The neighbourhood of the sea and cheap freights have favoured the worldwide distribution of this output. Next to Germany, the United States and France are the most important customers.

L. L. B.

BAUXITE IN ITALY.

Der Bauxit in Italien. By VITTORIO NOVARESE. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 299-301.

Bauxite has been vainly sought for many years in Calabria. In 1900, great masses of it were discovered by mere chance, at several localities in the Central Apennines, and the discovery was published by Prof. Mattirolo in May, 1901.

The Central Apennines consist mainly of huge massifs of Mesozoic limestone, ranging uninterruptedly in age from the Trias to the Upper Chalk and capped by the Eocene Nummulitic limestone. The bauxite occurs among the Urgonian or *Caprotina*-limestones (Cretaceous), at practically the same horizon as the bauxite in Southern France, in very extensive beds varying in thickness from 3½ to 26¼ feet. The mineral varies in colour from deep brownish-red to yellowish-red, light-pink or cream, is soft or crumbly, heavy (specific gravity 2·95 to 3·45), and of a peculiar pisolitic structure. The pisolitic spherules range in diameter from 0·04 to 0·40 inch. The mineral is evidently of the same age as the limestone-beds among which it is intercalated. Five analyses of the bauxite (from Lecce dei Marsi, Pietraroja, Pescosolido and Rocca di Mezzo) are tabulated, showing the percentages of alumina to vary from 47·44 to 58·85, and of iron sesquioxide from 18·62 to 36·37. Silica and titanium oxide are invariably present, but only one sample yielded phosphorus pentoxide (0·02). The Italian bauxite is rich in titanium, like some of the French bauxites and is easily attacked by sulphuric acid.

The author describes the deposits of Lecce dei Marsi and Pescosolido. both of which localities are favourably situated in regard to transport-facilities. They are practically untouched so far, only some preliminary exploration-work having been done on them—sufficient, however, to show that there is enough mineral in sight to supply the whole of Europe for many years to come. L. L. B.

CINNABAR-DEPOSITS OF MONTE AMIATA, TUSCANY.

(1) *Sulla probabile Esistenza di un Giacimento Cinabrifero nei Calcari Liasici presso Abbadia San Salvatore (Monte Amiata). By* B. LOTTI. *Bollettino del Reale Comitato Geologico d'Italia*, 1901, *vol. xxxii., pages* 206-215, *with* 1 *figure in the text.*

For more than 50 years the innumerable fragments of cinnabar disseminated in the detritic deposits which occupy a long belt of ground near Abbadia San Salvatore have stimulated prospectors to search for the original *locus* of the ore. These researches have been lately systematized, with the result of arriving at what is no longer a mere probability, but a practical certainty, in regard to the site of the cinnabar-deposits.

A detailed description is given of the stratigraphical succession in this area. In descending order, it is as follows:—

9. Pliocene marine shelly clays and sands.

8. Upper Eocene shales and marly limestones (with the latter, at Il Siele and Le Solforate, are intercalated clays containing cinnabar). Euphotides and other serpentine-rocks are associated with these.

7. Eocene sandstones, occurring in lenticular and wedge-like masses, occasionally dovetailed with the overlying limestones.

6. Nummulitic limestone, interbedded with red and grey clays.

5. Argillaceous shales and red and grey fucoidal limestones, alternating with reddish calcareous breccias (containing fishes' teeth) and manganiferous shales. Probably in part Lower Eocene and in part Upper Cretaceous.

4. Senonian limestones and shales, with manganiferous beds.

3. Upper Liassic shales of various colours, underlain by

2. Shales and cinnabar-bearing limestones, also belonging to the Upper Lias.

1. Middle and Lower Liassic limestones, passing in places into gypsum-beds.

Exploration-work has shown the chief cinnabar-deposit so far known below Monte Amiata to occur in a " chaotic mass " beneath a trachytic sill, 165 feet thick, which is itself overlain at Lame by a lacustrine deposit. Speaking generally, both the Eocene and Mesozoic formations hereabouts are ridged up into anticlines. The metalliferous (cinnabar-bearing) clays and sands occur also in the lake-bed above the trachyte, which itself has undergone dislocation, fissuring and slipping. It seems probable that all these cinnabar-bearing beds are the secondary stage of pre-existing deposits, and that the primary origin of them is connected with the emanations of sulphuretted hydrogen (*puttizze*) and the sulphureous thermal springs so common in this portion of the Monte-Amiata massif. The author thinks that more important cinnabar-deposits than those yet touched will be found in the Upper Liassic rocks of the district.

(2) *Das Zinnobervorkommen am Monte Amiata, Toskana. By* VINCENZ SPIREK. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 297-299.

In 1897, the author explained the results to which a prolonged study of these deposits had led him, in so far as their genesis is concerned. An acid solution of sulphates of mercury, iron, and other metals invaded the argillaceous limestones, whether of Liassic or Eocene age, and the subsequent chemical reactions, especially if hydrogen sulphide were present, favoured the formation of compounds of sulphur with calcium and the alkalies, causing the mercury to be precipitated from the now neutral solution in the form of red, crystalline cinnabar. This mineral variety can be originated only in the presence of highly sulphidic alkalies or alkaline earths in neutral or alkaline solutions, otherwise the sulphide of mercury appears as a black amorphous precipitate.

The argillaceous constituents of the limestone formed a sort of protective crust around the cinnabar, shielding it from re-solution, and in the hollows of the limestone, pyrites and selenite were also deposited in company with it. At a subsequent period, waters charged with carbonic acid enlarged the old and formed new hollows in the limestone, and the cinnabar was redeposited, this time in association with calcspar; or, in those cases where the neighbouring rocks are of a porous character (trachytes, sandstones, etc.) the cinnabar was actually carried away by the circulating waters. It occurs also as an impregnation in the most recent travertines.

The author's views have been confirmed by the researches of Mr. B. Lotti, one of the principal officers of the Italian Geological Survey, and by the observations of Mr. F. Amman, who manages the newly-opened mine of Abbadia San Salvatore.

The point that remains to be determined is the source of the sulphuric acid metalliferous solutions. They are evidently associated with the eruptive magma which formed the diabases and serpentines of the district.

(3) *Il Monte Amiata.* *By* A. VERRI. *Bollettino della Società geologica Italiana,* 1903, *vol. xxii., pages* 9-39, *with* 1 *text-figure and plate II.*

After a description of the Mesozoic and Tertiary sedimentaries which overspread the country around the central mountain-mass, the author devotes some pages to the volcanic rocks (largely rhyolites and trachytes) of which Monte Amiata itself is built up. He takes the opportunity of describing also the neighbouring volcanic mass of Radicofani, the mere remnant of a great basaltic eruption. Both that cone and Monte Amiata stood up possibly as islands in the later Pliocene sea, the volcanic phenomena dating perhaps precisely from that period. The moribund phase of vulcanicity is represented in the neighbourhood by numerous thermal springs, some of which are sulphureous, others ferruginous and highly charged with carbonic acid.

The cinnabar appears to be impartially distributed among the Mesozoic sedimentaries (Cornacchino mine); the Eocene marls, etc. (Siele and Solforate mines); the Eocene sandstones and Nummulitic limestones (Montebuono and Cortevecchia mines); the Pliocene sedimentaries (Saturina mine); and even among the trachytes and the overlying lacustrine deposits. It was worked by the ancient Etruscans, who used the ore simply as colouring-matter, and again in mediæval times (from 1200 to 1300). Wars and plagues decimated the country, and the mineral-industry was not revived there until 1846. In 1901, the mines of Abbadia, Cornacchino, Siele, Solforate, etc., were being actively worked, and the total output amounted to 278 tons of metallic mercury, the average yield of metal from the ore being 7·74 parts per thousand. Native mercury sometimes occurs in "drops" with the cinnabar, and thé other associates are iron-pyrites, gypsum (both amorphous and crystalline), calcite, and rarely quartz. At Selvena, stibine also occurs, while at San Martino cinnabar is found in an antimony-mine. The richest ore occurs in pipes (or pockets) of clay or sand among marly and other limestones.

The author summarizes the various opinions expressed by a succession of writers, from 1850 to 1903, as to the origin of the cinnabar-deposits. With differences as to detail, all are agreed that the genesis of these deposits is undoubtedly connected, directly or indirectly, with the volcanic phenomena of the neighbourhood. L. L. B.

THE BOGHEAD OF RESIUTTA, ITALY.

Resiutta: Cenni su quello Schisto bituminoso (Boghead). ANON. [16 *page pamphlet published by G. Smerzi e C., Venice,* 1901.]

The bituminous shale of Resiutta occurs about 3,300 feet above sea-level, and 2,600 feet above the Pontebbana railway-line, among (perhaps stratigraphically below?) the Triassic strata which are the predominant sedimentary formations of the Tagliamento river-basin. An analysis shows that it contains 47·47 per cent. of volatile matter (and water), 14·2 per cent. of fixed carbon, and 38·33 per cent. of ash. The percentage of sulphur is stated as 3·847, and of phosphoric anhydride in the ash 0·84. Distilled at high temperatures, the "boghead" produces a gas of exceptional illuminating-power. At lower temperatures it gives rise to a whole series of coal-tar products, and heavy and light oils. The specific gravity of the mineral is 3·12.

Experiments made by the City-of-Venice Gas Company showed that the distillation of the Resiutta boghead furnishes a gas which may be used either by itself as an illuminant, or for enriching or carburetting ordinary

gas: in the latter case the addition of a very small percentage of it produces a relatively considerable effect. The coke obtained from this boghead is of no value as a fuel, but if ground to powder it is available for bleaching and disinfecting purposes. L. L. B.

LIGNITES OF THE VICENTINO, NORTHERN ITALY.

Di alcuni Giacimenti lignitiferi del Vicentino. By T. TARAMELLI. *Giornale di Geologia pratica*, 1903, *vol. i., pages* 141-144.

The author agrees with Dr. Dal Lago in considering that the Eocene lignites which crop out at several localities in the province of Vicenza are not derived from peat, but from vegetable débris (trunks, branches and leaves) drifted into and accumulated in the lakes and estuaries of the early Tertiary period. He mentions, by the way, the bituminous lignites of Zovencedo and Monteviale, which yield but a small output and that of poor quality. These are of Oligocene age.

The most important deposits of the province lie among the hills through which the Agno, the Chiampo, the Alpone, the Illasi, and their affluents have cut their way. In the valley of the first-named a basalt-flow may be seen underlying the oldest Eocene, while elsewhere the Tertiary sedimentaries are traversed by intrusive dykes of later eruption. The oldest lignite-deposit in the region known to the author, that of Monte Pulli, rests upon *Alveolina*-limestones with intercalations of shelly bituminous marl. The mineral contains much sulphur, was first worked in 1841, and is once more the object of mining operations, although the deposit is not such as to admit of working on a very extensive scale.

Two beds of lignite have been traced in the neighbourhood of Castelvecchio, west of the Val d'Agno. Exploration-work in the commune of Cerealto has revealed other deposits, too thin to repay systematic working. The author visited a great many exposures of lignite, some of which were worked for a time, and then abandoned, and he concludes that, on the whole, the Monte Pulli deposits alone show promise of continuous remunerative working. The most recent statistics as to the annual output of lignites and bituminous schists in the province of Vicenza fix the amount at about 11,000 tons.

L. L. B.

THE ORE-DEPOSITS OF BROSSO AND TRAVERSELLA, PIEDMONT.

Die Erzlagerstätten von Brosso und Traversella in Piedmont. By V. NOVARESE. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 179-187, *with* 4 *figures in the text.*

Both these localities are in the district of Ivrea, on the margin of the Alps, near the point where the Val d'Aosta opens out into the great plain of the Po. The hills consist principally of mica-schists, in which are included numerous masses of eclogite and (though more seldom) extensive intercalations of crystalline limestones and dolomites. Between Brosso and Traversella, at the watershed which divides the Val d'Aosta from the Chiusella valley, a biotite-hornblende-diorite mass is intruded among the mica-schists, sending out numerous apophyses in the shape of small dykes or veins. In that neighbourhood the greatly disturbed mica-schists are traversed by numerous fissures striking north-westward and dipping regularly northward. These fissures are undoubtedly connected with the genesis of the ore-deposits.

The diorites have altered the limestones by contact-metamorphism, and in parts there has been a metasomatic replacement of limestone by oxides and sulphides of iron, and, secondarily, copper-pyrites. The phenomena are comparable with those observed in the ore-deposits of the Banate, and in the contact-rocks of the Christiania district.

The author then considers the ore-occurrences in detail, dividing them into three groups, the first of which comprises the magnetic iron-ores of the Bersella valley. Mining operations began here as long ago as 1487, but the industry is now at an end, and the old workings are difficult of access. Nevertheless, attempts are being made to revive mining here. In the upper part of the valley are the pure magnetites of Montajeu and Gias del Gallo (5,300 to 5,900 feet above sea-level): the ore is associated with more or less serpentinized olivine, and occurs in the form of intercalated beds among the limestones (which are in places highly silicified). In the lower part of the valley, are the iron- and copper-ore deposits of Traversella properly so-called. They are very near to the great diorite-mass, and with the magnetite are associated numerous metallic sulphides and a host of accessory ores and minerals. But the only ores that occur in payable quantity are the ubiquitous magnetite and copper-pyrites.

The second group comprises the specular iron-ore and pyrites of Brosso. From the point of view of facilities of transport these mines are much better situated than those of the Bersella valley. Working has been carried on in the Brosso mines without interruption, from the time of the ancient Romans down to our own day. The ore-bodies are in the form of banks or beds, conformably intercalated among crystalline limestones which strike westward, and dip 30 to 40 degrees southward. The thickness of the ore, however, varies considerably, from nothing to 200 feet or so. Evidently both the specular iron and the pyrites were deposited contemporaneously, and, although they are not found intimately intergrown, intrusions of the one are frequently observed in the other. The pyrites is very pure, and shows no trace of copper. Magnetic pyrites and magnetite occur, but are not worked hereabouts. The average annual production of the Brosso mines amounts to 25,000 tons of ore.

In the third group, the author ranges the metalliferous veins, which occur as infillings of the fissures mentioned in a previous paragraph. The ores in these are invariably sulphidic, and occasionally auriferous. Such fissure-deposits are common both to Brosso and Traversella, and the gangue consists of quartz and spathose iron-ore.

There is no doubt whatever that the genesis of all the ores described in this memoir is connected with the eruption of the diorite, which took place (in all probability) subsequent to the Oligocene folding of the Alps. Metalliferous vapours and solutions arose directly or indirectly from the eruptive mass, and made their way through the limestone-rocks. These were in part dissolved and leached out, and the ores and gangue-minerals were laid down in their place.

L. L. B.

THE CUPRIFEROUS DEPOSITS OF BENA DE PADRU, SARDINIA.

Il Crisocolla e la Vanadinite nella Miniera Cuprifera di Bena (de) Padru presso Ozieri. By DOMENICO LOVISATO. *Atti della Reale Accademia dei Lincei,* 1903, *series* 5, *Rendiconti, vol. xii., pages* 81-87.

A few years ago, some curious outcrops of copper-ore were discovered at Bena de Padru, on the slopes of Monte Tramento, about a third of a

mile distant from the high road, which runs from the ancient and wealthy borough of Ozieri to the railway-station of Fraigas. The ores occur in the belt of clay-slates, which alternate with the calc-schists overlying the granulite, the last-named being the basement-rock of the district. The discovery was made in the course of prospecting for plumbiferous veins, which, however, in Sardinia generally become barren as they enter the granulite: the copper-ores, on the other hand, are found near the contact with that rock. The exploration-work so far accomplished has revealed three separate "veins," consisting of strings of lenticles, largely of chrysocolla (hydrated silicate of copper) with quartz and calcite. Nearer the outcrop, the chrysocolla is almost entirely replaced by carbonates, such as malachite, azurite and cerussite. Deeper down chalcopyrite occurs in masses, traversed by thin veinlets of chrysocolla and quartz. Evidently we are dealing here with a deposit originally of sulphidic ores, decomposed by various agencies into oxides, sulphates, etc. The chrysocolla is generally amorphous, compact, varying in colour from turquoise-blue to green and bluish-white, and encrusts the schistose rocks. Chemical analysis shows it to contain about 40 per cent. of cupric oxide. In the centre of some of the lenticles is a reddish chocolate-coloured mineral, presenting the appearance of limonite: on analysis it is found to contain 34·5 per cent. of cupric oxide and 38 per cent. of iron oxides. It has been said that the purest copper-ores in these deposits contain as much as 67·7 per cent. of metallic copper. Near the contact with the granulite and in the granulite itself are small cubes and lumps of galena, also a vein of blende, 4 inches thick. Copper-ores are known to occur at other localities in Sardinia, but not in payable quantity, or at any rate in such conditions as to make working profitable. Whether the deposit at Bena de Padru is likely to prove of industrial importance, is a question which the author apparently leaves unanswered; but he hints at the difficulty of treating such a mixture of ores as that described. Vanadinite (chlorovanadate of lead) a rare mineral, and new to Sardinia, has been found in the same locality. L. L. B.

MANGANESE-ORES IN SARDINIA.

Dati analitici su alcuni Campioni di Manganese di Sardegna. By C. RIMATORI. *Atti della Reale Accademia dei Lincei, Rendiconti,* 1901, *series* 5, *vol. x., pages* 226-232.

The author points out that, although the importance and the wealth of the ore-deposits which the island of Sardinia can boast are well understood by his countrymen and by foreigners alike, but little has been done hitherto in the way of exact chemical analysis of the mineral products. He believes that new mineral species will be found to exist among the lead-, zinc- and silver-ore deposits of that favoured island. For the present, he confines himself to a study of the manganiferous ores. Of these he describes eight specimens, obtained respectively from Padria, district of Alghero (2), from the pale pink trachytes near Punta Giordano, from the limestone of Pozzomaggiore, from the volcanic rocks between Ploaghe and Chiaromonti, from the andesitic trachytes near Siliqua, from the deposits between Bosa and Montresta and those on the islet of St. Peter, between Capo Rosso and Capo Becco.

As a whole, the ores are varieties of pyrolusite, but that from Bosa-Montresta contains 20·68 per cent. of lead monoxide, and reminds one of the

wad of Baden recorded by Prof. Dana. Those from Padria and the Punta Giordano may be considered as varieties of psilomelane. Sometimes the manganese-ore occurs in the form of nodules and small concretions (Padria, Pozzomaggiore, etc.), elsewhere it is more or less intimately intermingled with the mass of calcareous or trachytic rock, or trachytic and andesitic tuff. Complete chemical analyses are tabulated by the author.

L. L. B.

PETROLEUM-DEPOSITS OF TRAMUTOLA, ITALY.

Il Petrolio nel Territorio di Tramutola (Potenza). By C. CREMA. *Bollettino della Società geologica Italiana,* 1902, *vol. xxi., pages xxxvi.-xxxviii.*

The author was recently deputed by the Department of Mines to report on the undoubted occurrence of petroleum in the district of Tramutola. Potenza. The oil-bearing area occupies at most 2 square miles, in the northern portion of the narrow valley, through which a streamlet called the Cávolo runs, to the west of Tramutola. Leaving out of account alluvial deposits (Quaternary) the strata are, in descending order:—Eocene clay-slates, marly limestones and sandstones; Cretaceous massive grey limestones; Upper Triassic dolomites (Hauptdolomit); and Middle Triassic siliceous schists and limestones. The bottom of the valley is almost entirely excavated in Eocene rocks; and in a little tributary glen, a rather brackish spring wells out, at the junction of the Eocene and the Triassic limestone, yielding continuously small quantities of petroleum with the water, and occasionally bubbles of gas. The oil is of a dark-brown colour, and has a specific gravity of 0·9. Another similar occurrence is cited farther north, also at the junction of Eocene and Trias; and a few shallow borings put down through the Quaternary deposits which overlie the Eocene in the little valley of Pietragrattata have also struck oil.

The author is disposed to infer that the more porous strata of the Eocene group in this district (the marls, and especially the sandstones) constitute the oil-reservoir: they are more or less regularly folded into anticlines, and alternate with impermeable strata. From the data at present available he concludes that there is little hope of this oil-field proving the site of a remunerative industry, but adds that this point can only be definitely settled by putting down a deep boring. L. L. B.

IRON-ORES IN SOUTHERN PORTUGAL.

Eisenerze im südlichen Portugal. By — WERNEKE. *Zeitschrift für praktische Geologie,* 1902, *vol. x., pages* 151-152, *with* 4 *figures in the text.*

A German company is engaged in working the deposits at Villa de Frades, in the district of Beja, province of Alemtejo. Prospecting has shown that the present area of mining operations in that region is susceptible of wide extension.

All the ores appear to be associated with the contact-zone of the greenstones, which are either interbedded as sills with the Archæan rocks or traverse these in the form of dykes. The ores occur sometimes in immediate contact with the greenstones, and sometimes in contiguous, apparently "contact-metamorphosed" strata of a slaty or calcareous character. The ore-bodies assume generally the shape of irregular lenticles.

In the Pichoto mine, the ore is a crystalline-granular magnetite with about 56 per cent. of iron, 7 to 8 per cent. of lime, 3 to 4 per cent. of silica, and 0·012 per cent. of phosphorus. At the outcrop the ore is changed to martite. On account of its excellent quality, it is much prized by the managers of several of the Rhenish-Westphalian blast-furnaces. The country-rock on the foot-wall side is greenstone partly very tough and compact, partly decomposed and shaly. The hanging-wall is limestone of a curiously granular structure, evidently much corroded by contact-metamorphic changes.

It appears evident that when the greenstones were erupted, aqueous vapours under high pressure were evolved from the eruptive magma, and, carrying along with them iron in solution from that magma, impregnated the neighbouring rocks. Such, at least, is the author's view of the genesis of the above-described ores. L. L. B.

PETROLEUM IN RUMANIA.

(1) *Sopra i Giacimenti petroliferi della Zona neogenica della Rumenia.* *By* G. DE ANGELIS D'OSSAT. *Giornale di Geologia pratica*, 1903, *vol. i.*, *pages* 69-77; *and*
(2) *Recherches sur la Composition chimique des pétroles roumains.* *By* P. PONI. *Annales Scientifiques de l'Université de Jassy*, 1903, *vol. ii.*, *pages* 65-80.

After pointing out that the petroleum-deposits of Rumania occur in three different formations:—(1) Cretaceous, as in the districts of Prahova and Dimbovitza; (2) older Tertiary; and (3) Neogene, in the sub-Carpathian région, the first author states that his attention was particularly directed to those of the third or latest series, and these are farthest away from the main Carpathian axis. The strata are Miocene and Pliocene marls, sands and conglomerates, with frequently-intercalated beds of gypsum and rock-salt. He sought in vain for fossils, and noted that the beds are generally much disturbed. He stoutly opposes, as regards that particular formation, the conventional hypothesis (true elsewhere in a vast number of cases) that the natural oil is to be looked for only below the anticlines. Nor does he regard that explanation as satisfactory which represents the petroleum-bearing beds as alternating with impermeable strata, and forming the remnant of a partly eroded anticline. His view is that in the Rumanian Neogene belt, oil should be sought for on exactly the same stratigraphical principles as water-bearing beds are sought for. It is true that the oil is lighter and flows therefore more easily, but he reminds us that in nature it is invariably accompanied by water.

With regard to the genesis of petroleum, although he favours on the whole the views of those who regard it as of organic origin, he points out that in some cases it may have been derived from some of the processes excogitated by those who uphold the volcanic theory.

The second author gives the continued results of his investigation into the composition of Rumanian petroleum, carried out largely by means of fractional distillation. He had already shown that the Colibasi oil contains tetramethylmethane, butane, propane and ethane. He proceeds to show that it also contains trimethylmethane (as does the Pennsylvanian and Ohio petroleum), secondary hexanes, benzene, tolulene, metaxylene (much more abundantly than the other aromatic carbides), mesitylene, etc.

L. L. B.

DIAMONDS IN THE URALS, RUSSIA.

Sur les Gisements de Diamants dans l'Oural. By W. Mamontow. *Bulletin de la Société Impériale des Naturalistes de Moscou,* 1902, *No.* 3, *page* 328.

The fortunate circumstance that, in the summer of 1899, the author was enabled to enrich the collection of the University of Moscow with the first Russian diamond possessed by it, is made a peg whereon to hang a compilation of the literature of the Ural diamonds. In the Northern Urals none of those precious stones have been discovered as yet, but no less than 16 diamantiferous deposits are dotted along the flanks, both eastern and western, of the Central and Southern Urals, and 222 diamond-crystals (or more) have been obtained there within the last 73 years. Generally they weigh less than a carat.

The diamond obtained by the author was a macled crystal, of a somewhat lenticular shape, weighing 1·107 carat, and was found by a peasant in the gold-bearing sands of the Polozhikha streamlet, in the neighbourhood of the village of Koltashi, domain of Neviansk, Urals. Since then, four more diamonds have been found in the same deposit. L. L. B.

THE MANGANESE-ORES OF YEKATERINOSLAV, SOUTHERN RUSSIA.

Die Manganerzlager in den Tertiären Ablagerungen des Gouvernements Jekaterinoslaw. By N. Sokolov. *Mémoires du Comité géologique, St. Pétersbourg,* 1901, *vol. xviii., No.* 2, 80 *pages, with figures in the text, and* 2 *plates.*

These ore-deposits, which are now the object of active mining operations, occur near the south-western border of the Government of Yekaterinoslav, east and west of the great grain-trading centre of Nikopol on the Dnieper. On the west, the ore-deposits cover an area of about 50,000 acres, in the upper basin of the Chertomlyk, a small affluent of the Dnieper. The ore consists of irregular nodular concretions of pyrolusite, of varying internal structure (vesicular, concentric, crystalline, etc.), which are sometimes dispersed without any sort of order through a black loamy bed, and sometimes are aggregated into a regular stratum at the base of the deposit. The ore-bearing bed rarely exceeds 5 feet, though occasionally it reaches 7 and even 10 feet, in thickness. Its floor is an apple-green siliceous clay, bearing many impressions and casts of Oligocene mollusca. The roof is usually a greenish-grey plastic clay, unfossiliferous, but evidently to be grouped with the overlying, abundantly fossiliferous, Sarmatic clays.

The ridge of old crystalline rocks of the Balka Malaja Kamenka cuts off the mining area just described, from the very similar manganese-ore deposits that lie east of Nikopol. They too occur as nodular masses and bands of pyrolusite among Oligocene loams and clays, but here they rest immediately upon the more-or-less weathered granite and gneiss. In places the overlying Sarmatic beds have been denuded away, and the deposits are mantled by sub-recent freshwater silts and æolian lœss. At Goredistshe and Krasnogrigoryevka, the base of the ore-deposit is formed by a stratum of pyrolusite-nodules, about the size of hazel-nuts, and varying in thickness from 8 to 30 inches. East of the Tomakovka river is still another ore-field, covering about 12,500 acres: very little exploration-work has been done on it so far.

Five manganese-mines altogether are at work in this region, with an estimated annual output of 85,000 tons of ore. Although certain other manganese-ore-deposits, on the Ingulez river below Krivòi Rog, are of

no industrial importance, they are important as showing that there is still a possibility of finding other workable deposits in the vast area that lies between the two rivers Ingulez and Bazaluk.

The author describes briefly some of the mollusca characteristic of the beds in which the manganese-ores occur. In the main, they are badly preserved, and the casts often consist largely of manganese. On the other hand, well-preserved sharks' teeth of different species are abundant, and the evidence which they afford has induced observers to assign the ore-deposits to the Middle Oligocene period. The author reserves, however, his final opinion on that point, until he shall have had time to study closely and work out thoroughly the available material.

He describes in some detail the petrographical and chemical characters of the ores, and it may be noted that in the western district (Pokrovskoye, etc.) they contain from 43 to 53 per cent. of metallic manganese, while in the eastern (Gorodistshe, Krasnogrigoryevka) they contain as much as 51 to 56 per cent. of the metal. The proportions of sulphur are infinitesimal, and those of phosphorus vary from 0·0175 to 0·36 per cent. The factor which mainly affects the quality of these ores is the varying amount of silica present; this, again, depends on the number of quartz-grains mechanically embedded in the ore. These pyrolusite-nodules of Yekaterinoslav recall vividly, both in outward appearance and in internal structure, the nodules dredged from the ocean-bed in the course of the deep-sea explorations of the "Challenger" and the "Albatross"; it is true, however, that the deep-sea nodules contain more iron and less manganese. In point of fact, the lithological and palæontological evidence taken together shows that the Yekaterinoslav deposits were formed in shallow water, not very far from a coast line. The author reconstructs in imagination the Oligocene geography of Southern Russia, and discusses at great length the possible origin of the manganese. He seems to think that it may have been derived from marine plants, peculiar to the Oligocene seas of Southern Russia and Transcaucasia, which had the power of elaborating or at least concentrating manganese compounds within themselves.

L. L. B.

THE HÆMATITE-DEPOSITS OF THE POKROVSKAIA ESTATE, SOUTHERN RUSSIA.

Sur le Gisement de Minerai de Fer dans le Domaine Pokrovskaia, Propriété du Grand Duc Michel Nikolaievitch. By N. SOKOLOV. *Bulletin du Comité géologique, St. Pétersbourg,* 1900, *vol. xix., pages* 407-421, *and plates VII.-VIII. (map and section).*

The Pokrovskaia estate, the property of the Grand Duke Michael Nikolaievich, is situated at the south-western extremity of the Government of Yekaterinoslav, at the confluence of the Bazaluk with the Dnieper. The brown hæmatite occurs in fairly large masses, among mottled clays of a vivid red, pink, violet, and lilac colour. The "nests" of ore attain a maximum thickness of 3½ feet: analyses have shown that the hæmatite contains between 40 and 50 per cent., sometimes even more, of metallic iron, mere traces of sulphur, and very small proportions of phosphorus (the percentage of phosphorus pentoxide varying from 0·09 to 0·15). Some samples contain chromium. The ore-deposits cover an area of about 18,000 acres; the mottled clays are overlain by the Oligocene sands and clays containing manganese-ores, and they rest upon ancient crystalline rocks. Among

these are granites, gneisses, diorites, amphibolites, chlorite-schists, talc-schists and quartzites seen along the banks of the Chertomlyk and the Solenaia, which streams form in part the boundaries of the estate. Exploration-work has gone down to a depth of 82 feet below the surface (at the Nijni Perevitzkaia farmstead) without touching the bottom of the hæmatitic clays. The projected railway from Nikopol to Krivòi Rog will much facilitate the working of these deposits. L. L. B.

THE IRON-ORES OF MOUNT MAGNITNAIA, RUSSIA.

Le Mont Magnitnaia et ses Alentours. By J. Morozewicz. *Mémoires du Comité géologique, St. Pétersbourg,* 1901, *vol. xviii., No.* 1, 106 *pages, with figures in the text,* 6 *plates and* 1 *geological map.*

Mount Magnitnaia rises to the height of 1,892 feet above sea-level, on the eastern slope of the Southern Urals, 149 miles distant from Miask, the nearest railway-station. In reality it is a massif consisting of several hills rather than one, and it dominates a hilly plateau which passes eastward into the Kirghiz steppes. It covers a surface of 9¼ square miles, and the minimum amount of iron-ore which it contains is estimated by the author at upwards of 48,000,000 tons.

He gives first of all a petrographical description of the rocks of the massif, pointing out that these are essentially of eruptive origin. They consist of granites, felsites, diorites, syenites, porphyries, diabases, and a rock which he names "atachite," from its occurrence on the crest of Mount Atach, the highest summit of the Magnitnaia massif. This rock is "briefly" defined as a cordierite-sillimanite vitro-orthophyre.

To the crystalline rocks of secondary formation belong the granatites or garnet-rocks, and the associated magnetite, martite and hæmatite-deposits. The ore-deposits, although not strictly continuous, cover an area of about 500 acres: there are frequent alternations of barren rock (decomposed garnet-epidote rock and kaolin). Magnetite is the predominant ore: it occurs occasionally in black compact masses that look as if fused. This compact variety often contains as much as a third of its volume of quartz, while the non-compact variety frequently consists for about one half of garnet. In many places the magnetite is partly altered into martite. On an average, the ore consists of: magnetite, 25 to 50 per cent.; martite, 32 to 58; quartz, 10 to 12; garnet, 2 to 18; kaolin, *nil* to 5. Hæmatite occurs both as an oxidation-product of magnetite, and independently in the form of lamellar crystals in the garnet-rock. In mass it is frequently porous, and is associated with quartz and clay, as well as pyrites and gypsum. The average percentage of its constituents, deduced from these analyses, is as follows:—hæmatite, 67 to 98; quartz, *nil* to 20; kaolin, 2 to 13; and pyrites, *nil* to 3.

In the fissures of the altered argillaceous and garnet-bearing rocks a concretionary ore occurs, which is found to contain 10 per cent. of pyrolusite, 80 per cent. of limonite, and 10 per cent. of clay.

The general character of the iron-ore deposits is summarized as follows:—They occur in altered garnet-epidote and kaolin-rocks, which rest upon more or less decomposed augite-felspar rocks. The greater the alteration that the garnet-bearing rock has undergone, the richer as a rule is the deposit. The ore alternates very irregularly with the country-rock, amid which it

occurs in masses, nests, or beds. The deposits are generally to be found on the slopes or at the base of the Magnitnaia massif. To judge from the borings, the ore-deposits show no particular change down to a depth of 250 feet. Impregnations of pyrites begin to be observed at about 50 or 60 feet from bank, and nearer the surface gypsum takes the place of pyrites.

The various theories by which it has been sought to account for the origin of the Magnitnaia ores are discussed, and it may be observed in passing that the analogy of these ores to the famous deposits of Blagodat and Vysókaya has been generally noted. The author concludes in favour of a gradual hydro-chemical metamorphosis of the eruptive augite-felspar rocks by the intermediary of the garnet-rock. It may be observed that the eruptives themselves contain a considerable amount of primary magnetite, which was probably one of the first constituents to crystallize out of the igneous magma; so much indeed, that one-tenth of their weight could have been transformed into ore. It is further shown that, in the Urals at least, augite very commonly decomposes into chlorite and garnet, setting free a certain amount of iron-oxide. Garnet itself, decomposed in presence of water and carbonic acid, may give up as much as 30 per cent. of free iron-oxide. (It will be remembered that in certain European localities pseudomorphs of red and brown hæmatite after garnet are known to occur; and that garnet is a frequent associate of metalliferous deposits.) Quartz and calcite represent the last phase of the cycle of hydro-chemical phenomena, which resulted in the separation and accumulation of a considerable quantity of free iron oxides, by the agency of garnet and epidote.

The few outliers of sedimentary rocks that denudation has spared in this neighbourhood are Lower Carboniferous and Middle Devonian limestones.

L. L. B.

THE IRON-ORES OF TROÏTSK, NORTHERN URALS.

Sur le Minerai de Fer de Troïtsk (Oural du Nord). By L. DUPARC and L. MRAZEC. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1903, *vol. cxxxvi., pages* 1409-1411.

Troïtsk is situated on the left bank of the Kosva river, in the Government of Perm. Here "granite-porphyry" crops out amid the Lower Devonian strata, and with it is associated the occurrence of iron-ores. A band of magnetite mixed with hæmatite, from 3 to 56 feet in thickness, is observed wherever the igneous rock appears, to have developed contact-metamorphism in the sedimentaries of earlier age than the Devonian.

The Osamka mine is worked opencast at seven successive horizons. At the lowest level, bands of ore varying from 20 inches to 6½ feet in thickness are separated by thin partings of micaceous hornstones; they form here a very flat anticline, which at the succeeding higher levels becomes more and more accentuated, until it passes into a "contortion-fault." The total thickness of ore and partings in the anticline amounts to 56 feet, the whole dipping gently northward below the porphyry: while near the southern end of the mine ore-bands and partings abut against a wall of porphyry. The structure of the ore varies: sometimes it is absolutely compact, in other cases the magnetite-crystals form a sort of meshwork amid the interstices of which white mica has crystallized out; in yet others, the magnetite in the form of isolated crystals is abundantly disseminated throughout a micaceous and lamellar groundmass. It is perfectly evident that

the magnetite is the result of metamorphism, induced by the "porphyry" or granitic magma, in the strata which are now hornstones. That this took place before Devonian times is proved by the fact that pebbles of the "granite-porphyry" occur in the Lower Devonian conglomerates. The somewhat complicated relations of the rocks are explained by earth-movements, both pre-Devonian and post-Devonian. L. L. B.

THE TURGITE-ORES OF RUSSIA.

Die Turjiterze Russlands. By PROF. J. SAMOJLOFF. *Zeitschrift für praktische Geologie*, 1903, *vol. xi.*, *pages* 301-302.

Turgite, a hydrated oxide of iron, has often been confounded with hæmatite and limonite, and there are still some mineralogists who refuse to regard it as a distinct mineral species. Its chemical formula, as given by the author, is $2\,Fe_2O_3, H_2O$, and he has described elsewhere important deposits of it in the Southern Ural (Bakal mines, Zlatóust). The mineral was first identified by Hermann in 1845 from the Turginsk mine, Bogoslovsk district, Northern Ural.

Turgite-ores have been recently discovered at several localities in Central Russia, and a good example of their composition is given by the chemical analysis of one from Vladimirovka, in the Government of Tula. This shows the following percentages: iron sesquioxide, 87·93; silica, 2·12; alumina, 1·6; phosphorus pentoxide, 1·57; and combined water, 6·52.

Close examination of iron-ore deposits in various parts of the world is likely to prove, in the author's opinion, that turgite is of far more widespread occurrence than is generally imagined. L. L. B.

GLAUBER'S SALT-DEPOSIT IN TRANSCASPIA.

Glaubersalzschichten im Adschidarja. By DR. CARL OCHSENIUS. *Zeitschrift für praktische Geologie*, 1903, *vol. xi.*, *page* 33.

The report recently published by the Russian Ministry of Agriculture, on the results of a Government expedition to the Gulf of Achidarya, on the eastern coast of the Caspian Sea, announces that a deposit of Glauber's salts, some 6½ feet thick, occurs on the sea-bottom there, and increases annually in thickness by about two-fifths of an inch. Similar occurrences are reported from several of the shrunken lakes of the Aralo-Caspian depression, and these are all deemed of high importance from the point of view of Russian chemical industry. Indeed, it is asserted that they may enable Russia in time to become the world's provider for soda.

Meanwhile, it may be observed that the neighbourhood of the Achidarya is unmitigated desert, that the deposit itself lies under water, and that the facilities of transport are not particularly favourable. L. L. B.

PLATINUM IN THE NICKEL-ORES OF NORWAY.

Platingehalt im Norwegischen Nickelerz. By PROF. J. H. L. VOGT. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 258-260.

In view of the fact that the Norwegian deposits of nickel-ore and magnetic pyrites are very similar, both geologically and mineralogically to

those of Sudbury in Canada and Klefva in Sweden, there was an *a-priori* probability that in Norway too the nickel-ores would be found to contain platinum. In order to settle this point, the author made careful chemical analyses of specimens from Ringerike and Evje. The former yielded, as well as platinum, minute proportions of osmium, iridium and gold, the latter traces only of platinum and gold. A comparison of the analyses of the Norwegian, with those of the Canadian ores, shows that the ratios of percentages, between silver and nickel and gold and platinum respectively, are identical in the ores from either side of the Atlantic. Moreover, it is now possible to state, that whenever nickel-ores have been examined for platinum and gold, they have invariably been found to contain both these precious metals. Whence the author concludes that the gabbro-magma from which the nickeliferous magnetic pyrites-deposits were originally separated out by differentiation must have contained gold, platinum and silver, and that the mineralogical composition of this magma must have been practically the same in Europe as in America.

He lays stress on the point that platinum in the native state, occurring as it does chiefly in olivine-rocks and serpentines derived therefrom, is also the outcome of magmatic differentiation. On the other hand, platinum is either absent or present only in infinitesimally minute proportions, in such ore-deposits as were formed by hydrochemical processes. The reason probably is, that such processes did not develop a sufficiently high oxidizing or chlorinating power to dissolve the extremely refractory platinum-metals. It is easier to bring gold into solution than platinum, and thus while the latter is of more widespread occurrence in basic eruptive rocks, the former is correspondingly more abundant in "hydrochemical" ore-deposits. The occurrence of the above-mentioned precious metals in the Norwegian nickel-ores does not seem likely to prove industrially important. L. L. B.

COPPER-ORE DEPOSITS IN SERVIA.

Die Kupfererzlagerstätten von Rebelj und Wis in Serbien. By R. BECK *and* W. VON FIRCKS. *Zeitschrift für praktische Geologie,* 1901, *vol. ix., pages* 321-323, *with 3 figures in the text.*

The deposits described in this paper occur in north-western Servia, south-west of Valjevo, in the river-basin of the Yablonica, one of the tributaries of the Kolubara. The cupriferous belt strikes north-west and south-east, and the ores are associated with masses of serpentine which appear to have thrust themselves among the Mesozoic sedimentaries on the northern slope of the Povljen mountain-range. So far, mining-operations have been confined to the deposits of Rebelj and Wis, in the neighbourhood of the village of Brezovica.

At Rebelj, the pale-grey, argillaceous, calcite-veined Triassic limestone is intruded into by an apparently-conformable sill of serpentine, 197 feet thick, the outcrop of which can be traced for about a third of a mile. The serpentine is highly decomposed, much slickensided, and very rich in magnetite. Amid it lie lenticular masses of ore, which may reach a maximum of 98 feet in length and 53 feet in thickness. Peripherally they consist of copper-pyrites with which iron-pyrites and serpentine are sparsely intermingled, and in that portion contain up to 15 per cent. of copper. They are poorer towards the centre, which consists largely of cubic crystals of iron-

pyrites, accompanied by copper-pyrites, calcite and serpentine: here the percentage of copper is generally less than 5. At the outcrop, the ore-bodies pass into a cavernous brown hæmatite, containing from 10 to 15 per cent. of copper (associated with it are fine acicular crystals of chalkotrichite, incrustations and crystals of azurite and malachite, and remnants of undecomposed copper-pyrites). It is to be observed that the serpentine at the outcrop, quite apart from the cupriferous ore-bodies, is often rich in brown hæmatite, which is doubtless derived from the decomposition of the magnetite in the serpentine.

At Wis, a mine buried in the primæval forest, the Triassic limestone is again broken through by a dyke-like mass of serpentine; but along one of the salbands a mass of diabasic thrust-breccia intervenes between the serpentine and the limestone. The ore consists of irregular lumps of copper-pyrites, mingled with but little iron-pyrites and serpentine: these lumps may weigh as much as a ton, they contain from 8 to 14 per cent. of copper, and occur always very near the junction with the breccia.

Similar cupriferous deposits are found along the same mountain-range at Radanovci, Wuinovatz and Staninareka. They are all comparable genetically with the occurrence at Monte Catini, in Tuscany; with the difference that, in Servia, the concentration of the ore in its present form took place during the secondary, complete metamorphosis of the olivine-bearing mother-rock. L. L. B.

THE COAL-FIELD OF BELMEZ, SPAIN.

Memoria descriptiva de la Cuenca carbonifera de Belmez. By L. MALLADA. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol.* vi., *pages* 1-80, *with* 4 *text-figures, and plates* I.-II.

Only a small portion of this basin has been properly explored and mined in underground workings, and the author says that much work remains to be done before the field is properly developed. The seams are extremely irregular, much dislocated, and the measures are in most cases covered by a thick mantle of drift-deposits.

The exhaustive memoir under review is divided into three principal sections, the first of which deals with the general geology of the coal-basin. the second is a detailed description of the mines, and the third is devoted to industrial considerations.

The coal-basin forms a belt of about 37 miles in length and 1¼ miles in mean breadth, extending from north-west to south-east, parallel to the Guadiato river, and occupying an area of some 56 square miles. The Coal-measures are flanked on either side by older strata, and by igneous rocks which are intrusive in the Coal-measures themselves as well as in the older strata. The last-named comprise Archæan crystalline schists, Cambrian slates, Silurian quartzites, Devonian slates, highly-fossiliferous limestones and grits. The igneous dykes, bosses, and sills are generally either quartz-porphyries or diabases, and they are of more frequent occurrence at the northern than at the southern extremity of the basin. About four-fifths of the basin is masked by red stony clays, and more or less conglomerated gravels of Quaternary age.

Within the basin, the following rock-groups are recognized: Carboniferous Limestone, sometimes jammed in by faults among the Coal-measures, barren Culm-measures (also termed by the author Lower Coal-measures), and the

Coal-measures proper. In no other district in Spain, or indeed in Europe, are Coal-measure conglomerates so extensively developed. Not only do they occur at the base, but are intercalated at various horizons with the shales and grits which accompany the coal. Another characteristic is the abundance of clay-ironstone. The coal varies in quality from anthracitic, dry, or semi-bituminous, to bituminous. Some of the last-named coals are very gassy, others not at all so. The variations in thickness of the seam are extreme, ranging from 131 feet in one place to a few inches in another. In fact, the definition "pockets" would be more properly applicable to the present condition of the deposits than the term "seams." Taken as a whole, the Coal-measures strike north-west and south-east, and dip south-westward, with local divergencies from these directions.

For the purpose of a detailed description the mines are divided into four groups: (1) from the northern boundary to the town of Belmez; (2) between Belmez and the Albardado stream; (3) between the Albardado and Espiel; and (4) between Espiel and La Ballesta. The highest seams are those nearest the Guadiato.

The history of mining industry in the basin dates back to 1790, and at the present day the field is practically parcelled out among six great companies. Tables of analyses of the various coals are given, the maximum and minimum percentages being as follows: carbon, 75 and 48·4; volatile matter, 43·2 and 13; ash, 12 and 2·6. The seams worked in the Terrible and Santa Elisa mines are especially suitable for gas and coke manufacture. Some of the coals are very tender, and make a lot of small coal.

The deepest shafts described are the Camondo, on the Santa Elisa property, which goes down to a depth of 875 feet; and the Canóvas, on the Cabeza de Vaca, 836 feet. The average wage, including workmen both above and below ground, is 2s. 8d. per day, and the cost of output per metric ton of coal varies between 7s. and 9s. 6d. In comparison with other coal-fields, such as that of the Asturias, the cost of pit-timber is excessive. Pine-timber (all but exclusively) is used, imported from Portugal or brought from Huelva and certain districts of the Sierra de Córdoba. The coal-tubs are generally built up in the mines themselves, the necessary iron or steel being imported from foreign countries direct, or brought from Córdoba.

The cost of pumping varies greatly from mine to mine, but that of ventilation and lighting is more generally uniform. Guibal, Ser and Mortier fans are used, and safety-lamps are very generally employed. In the mines of the Santa Ana group, however, and La Calera, fire-damp being present (when present at all) in extremely small quantities, it is thought safe to use naked lights.

The total output from 1861 to 1900 inclusive was close on 7,000,000 tons, of which 1,850,000 belong to the quinquennium 1896 to 1900. The author believes that a good deal more coal, immensely more, will be got from this basin in the future. In fact, given the proper plant and improved means of transport, the output within the next twenty years could be increased fivefold.

L. L. B.

THE VALVERDE BORING, CIUDAD REAL, SPAIN.

Sondeo de Valverde (Ciudad Real). By CASIMIRO COELLO. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi.*, *pages* 253-256.

About the end of 1899, in the township of Valverderc, west of Ciudad Real, and very close to the Guadiana river, in sinking a well, rather sandy white

clays with carbonaceous patches were struck, at no great depth from the surface. This gave rise to the expectation that coal-bearing beds might be found at an easily accessible depth, and so a company was formed and a mining concession duly obtained. There was some justification for this, as the geological structure of the country is that of a wide basin, surrounded by a rim of Silurian rocks, and stretching between the western spurs of the Sierra de Alarcos and the eastern spurs of the Alcolea range, down to the Guadiana. Boring operations were commenced in the autumn of 1900, but were stopped at a depth of 112 feet, on account of the abundant inflow of water and the loose texture of the rocks bored through, which were continually falling in. The strata consisted of clays, marls and sands, some of which were carbonaceous and pyritous, with a remarkable plant-bed in which the leaves still retain some of their green coloration.

In the spring of 1901, operations were resumed some 90 feet west of the first spot, but the boring was stopped at a depth of 217 feet, on account of an accident to the apparatus. Then with a diamond-borer, an attempt was made nearer the centre of the basin, south of the first locality chosen, and a depth of 315 feet was reached (in grey grauwacke with ferruginous inclusions) but the expected coal-formation was not met with. As a matter of fact, after passing through Quaternary and Miocene strata the Silurian had been struck, thus showing that the Coal-measures are absent.

L. L. B.

THE ORIGIN OF THE PYRITES-DEPOSITS OF SOUTHERN SPAIN.

Ueber das Auftreten und die Entstehung der Südspanischen Kieslagerstätten. By DR. F. KLOCKMANN. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 113-115.

The author publishes here the conclusions at which he has arrived, after seven years' renewed study on the spot, concerning the famous pyrites-deposits of the provinces of Huelva, Seville and Alemtejo.

In all cases, the ore-beds are intercalated conformably with the surrounding slates. The imaginary unconformities which have been recorded are the outcome of hasty or inaccurate observation. Moreover, the ore-beds are confined to the Culm-measures, the supposed intercalation of some of them among the Silurian strata being now disproved. With the ore-occurrences are associated eruptive sills—consisting of quartzose and quartzless porphyries, porphyrites and diabases; also amygdaloidal tuffs. The sills, too, are conformably intercalated among the Culm-measures.

After enumerating the reasons which forbid him from regarding the pyrites here as in any sense a vein-deposit, the author points out that only one explanation accounts satisfactorily for the origin of the ore—it is a concretionary segregation within a plastic clay-slate mud, saturated with the chemical elements of pyrites. It is very possible that this segregation was initiated and accompanied by precipitations of pyritic matter. The sills and tuffs, doubtless the outcome of submarine volcanic phenomena, were the "ore-bringers."

The author traces a genetic relationship between the Spanish pyrites-deposits and, among others, the blackband ironstones and sphærosiderites of the Coal-measures.

L. L. B.

COPPER-ORES IN THE TRIAS OF MINORCA AND GRANADA, SPAIN.

Criaderos sedimentarios de Cobre en Menorca y en Granada. By R. S. LOZANO. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi., pages* 233-244.

The author points out that a character common to nearly all the cupriferous deposits that are contemporaneous with the sedimentary rocks in which they occur, is the association of plant-remains around which the copper-minerals are more or less concentrated, or sometimes actually take the place of the plants by metasomatosis. Among such deposits are those of Mansfeld, of Bohemia and of Russia (Perm). It it true that others, although stratified, contain no demonstrably organic remains, such as those of the Caucasus, El Boleo and Rammelsberg. With the foregoing he is inclined to correlate the Spanish occurrences which he describes.

In various localities of the Island of Minorca, intercalated among the Lower Triassic sandstones, are cupriferous deposits, which have long been known, but do not appear to have attracted serious attention until quite lately. The best known district lies in the central region of the island, between Mercadal and Monte Toro. The copper-ore occurs here in a chemically-deposited rock, made up of carbonates of lime and magnesia, with a large percentage of silica, and some alumina: the rock is defined by the author as a magnesian marl, of a pale-grey colour, contrasting vividly with the red clays and sandstones among which it is intercalated. This marl varies in thickness from 1½ to 6 feet. The ore is chiefly copper sulphide, containing no less than 64·2 per cent. of the metal. It impregnates the lignite which occurs in the marl, and the plant-fibres would appear to have been in many cases metasomatically replaced by copper-compounds. Most frequently, however, there is an intimate intermixture of coaly substance and chalcopyrite. Sometimes there are two bands of lignite, sometimes it pinches out altogether. The ore where purest contains as much as 79·8 per cent. of copper, and analysis has revealed the presence of 0·016 per cent. of silver. So far as that district of the island is concerned, only this one cupriferous horizon is known. It is worked in La Rubia mine, which consists of a haphazard labyrinth of galleries, communicating with three comparatively shallow pits, that serve the purposes of drainage, haulage and ventilation. It is not found necessary to use timbering in the mine, as the rocks do not easily fall in.

The Trias covers a considerable portion of the northern area of Minorca, and in this region undoubted occurrences of copper-ore are recorded from various localities over a belt some 17 miles in length. In Lower Triassic times there must have been a great lake here, the waters of which were saline and alkaline, and contained in solution copper-salts, derived either from cupriferous emanations proceeding from volcanic rocks, or from the decomposition of pre-existing metalliferous veins. The lake was probably covered in places with a floating mass of vegetation, and as the plants decayed and fell to the bottom, the organic matter, by reducing the copper-salts, brought about their precipitation in the form of sulphides.

About 15½ miles from Granada, near the road to Guadix, in a mountainous district about 1,000 feet above sea-level are the metalliferous deposits of El Molinillo. The most important ore is a highly argentiferous galena, but there are also cupriferous deposits of the same age, nature and origin as those described in Minorca. Analysis of a sample of chalcopyrite mixed with lignite, yielded 59·76 per cent. of copper. Nothing can be said as

yet as to the possible industrial importance of the copper-ores here, as attention has been so far all but exclusively devoted to the very rich galena-deposits.
L. L. B.

IRON-ORES OF RÍO IBOR (CÁCERES), SPAIN.

Datos geológico-mineros de la Provincia de Cáceres: Criaderos de Hierro del Rio Ibor. By R. S. Lozano. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi., pages* 205-219.

The mines with which this memoir deals are situated in the south-eastern corner of the province of Cáceres, in a mountainous region known as the Sierra de Guadalupe. Ridges of quartzite running south-east and north-west divide a series of narrow, picturesque and fertile valleys one from the other. The greater number of the streams flow into the Río Ibor, which is perennial, and a tributary of the Tagus. Most of the roads are mere wheel-tracks, but there is a good cart-road at Almaraz, which is 8¼ miles distant from the railway-station of Navalmoral de la Mata, on the main line from Madrid to Lisbon. The nearest ports of embarkation, Seville and Lisbon, are respectively 159 and 223 miles distant, as the crow flies.

The strata are mainly of Silurian and Devonian age, and iron-ores occur in both series. Hæmatites, frequently manganiferous, infilling fissures or intercalated among the bedding-planes, are found in the basement Silurian quartzites. They are still more abundant at the contact of the quartzites and the slates, and are indicated by gossans exceeding 3 feet in thickness. The ore is extremely tough, more or less silicified, and the manganese-content is often very high. But these Silurian hæmatites of the Río Ibor are not developed in sufficient quantity to repay working on a large scale in modern times. They are neither true vein-deposits nor great mass-deposits.

Along a narrow belt of Devonian limestone stretching for about 25 miles from south-east to north-west, where the basement-beds are highly metamorphosed (dolomite, siderite, etc.), occur manganiferous hæmatites and limonites, which in some localities were known and worked in olden days. There is not much opportunity in these deposits for opencast working now, and most of the mining would have to be done underground. There is no reason to believe that the ore will be found to increase in quality and quantity in depth, but rather the contrary.

The author describes the mines which he visited, being those of San José No. 3 (no good ore visible); Immaculada Concepcion (a specimen of hæmatite from this yielded on analysis 43 per cent. of iron, 1·33 per cent. of manganese, 0·25 of sulphur, and 0·85 of phosphorus), which appears to be the most promising mine of all; San Luis, San Cesáreo, San Antonio No. 2, San Miguel No. 2, San Pablo, San Fabián, San Policarpo, San Juan Nos. 1 and 2, Viriato, San José Nos. 1 and 2, Virgen de la Montaña, Nuestra Señora de Guadalupe, San Ildefonso, San Benito, San Andrès and San Fausto. Taking into consideration that the average percentage of iron in all the ores assayed from these mines is 46½ and that of manganese 3¼, the author does not opine that they would repay the very heavy cost of transport under present conditions. The building of a light railway to Seville would cost something like £1,000,000, a sum which could hardly be reimbursed by the output of all the mines in the district put together.
L. L. B.

ROCK-SALT AND OTHER USEFUL MINERALS IN THE MESOZOIC ROCKS OF SPAIN.

Explicación del Mapa geológico de España: Sistemas permiano, triásico, liásico, y jurásico. By L. MALLADA. *Memorias de la Comisión del Mapa geológico de España*, 1902, *vol. iv.*, *pages* 274-305, 504-506.

Taking the geological systems considered in this volume in descending order, we may note the occurrence of hæmatite in the Upper Jurassic limestones of the Sierra de Albarracin (Teruel), and in the Liassic clayey limestones of various localities of the province of Tarragona. These deposits are, however, nowhere of industrial importance. Iron-pyrites occurs in cubes, the sides of which measure as much as 2 inches, in the Bajocian limestones of the neighbourhood of Agreda (Soria) and in the Liassic strata of Anguiano (Logroño). Pyrolusite occurs in a belt about 1,500 feet wide and over 1 mile in length, in clays interbedded with Upper Jurassic limestones, in the province of Teruel. It has been worked in a most irregular and desultory fashion, and subsidences have taken place every now and then, with the result that mining operations have been interrupted for many years at a stretch. A pocket of manganese has also been worked about 1,500 feet east of Coll de Arnat, in the province of Lérida.

Unimportant occurrences of blende, calamine, galena, cupric carbonate, and nickel-ore are recorded from the Jurassic limestones and sandstones of various localities. Of some interest, however, are the lignite-deposits associated with clays and sandstones, intercalated among the Liassic limestones in the provinces of Soria and Zaragoza. Over a length of about 2 miles four principal seams are traced, with dips varying from 40 to 60 degrees north-eastward. These four main seams vary in thickness from 12 to 20 inches, and the mean of three analyses shows the following percentage-composition: carbon 48·1, water and volatile matter 46·48, and ash 5·4. The heating power is equal to 6,368 calories, and this lignite is suitable for purposes which demand the use of a long-flame coal. Unfortunately these deposits are by no means so extensive as they were originally supposed to be, and the author's view of their industrial importance is unfavourable.

Thermal springs of medicinal value occur among the Jurassic rocks of various provinces.

Coming now to the Triassic, we find that in Spain, as in so many other parts of the world, this system is characterized by the occurrence of rock-salt deposits and brine-springs. More than 90 per cent., indeed, of the salt-springs known in Spain well out among the gypsiferous marls and clays of the Trias, from Santander in the north to Málaga and Cádiz in the south. In the province of Santander are rock-salt deposits of considerable thickness (30 to 150 feet). The salt obtained at Imón in the province of Guadalajara is largely consumed in Madrid, but the salt-production of the province could be much increased, were it not for the "inborn indolence of the country-people." A fairly detailed description is given of salt-mines in the provinces of Burgos, Cuenca and Valencia, and of the dried up salt-lagoon of Fuente Piedra (Málaga), etc.

As to metalliferous ores in the Trias of Spain, the most abundant and widespread are the iron-ores, especially in the provinces of Almeria and Murcia. Certain hæmatite-veins which traverse the crystalline schists of the first-named province pass up into the overlying Triassic limestones, becoming richer and less siliceous as they pass upward. The percentage of metallic

iron averages from 45 to 50. It is asserted that in the three provinces of Almería, Murcia and Granada, there are more than 25,000,000 tons of this ore in sight.

Plumbiferous deposits in Spain usually occur in older rocks, nevertheless galena-deposits of considerable importance have long been worked among the Triassic limestones of the Sierra de Gador (Almeria): and lead-ores are found in rocks of similar age in the provinces of Granada, Logroño and Teruel, and in the island of Ibiza or Iviça.

Copper-ores in the Spanish Triassic are of widespread occurrence, but nowhere do they seem to be of industrial importance. The latter statement holds good of the blende and calamine recorded from the provinces of Granada and Almeria, the cinnabar from the Sierra Nevada and elsewhere, the Triassic lignites of Santander, Alicante, etc. L. L. B.

ASBESTOS-DEPOSITS IN SWITZERLAND.

Die Asbestlager der Alp Quadrata bei Poschiavo (Graubünden). By Dr. Chr. Tarnuzzer. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 217-223, *with 2 figures in the text.*

These deposits occur high up on the divide between Val Quadrata and Val Canciano, in the commune of Poschiavo, in the Canton of Grisons, some 3,300 feet above the village (or 6,800 feet above sea-level), very near the Italian frontier. The asbestos occurs in the Green Slate Series, or serpentinous Malenco rock, as the older Swiss geologists termed it. Mr. Bodmer-Beder recently made an exhaustive microscopic study of the rock, and pronounces it to be a slaty harzburgite-serpentine rock. The same authority considers that originally it was an eruptive mass made up of bronzite, olivine and diopsidé, altered to its present condition by thrusting and folding, complicated by the metamorphic effects of thermal and aqueous agencies.

The percentage of lime (5·67) yielded by the chemical analysis of the asbestos leads to the inference that the typical mineral hereabouts consists of about 7 parts of chrysotile- and bronzite-bastite asbestos, with 3 parts of tremolitic hornblende and diopside. In some of the mines, however, it is purely tremolitic asbestos, and in other places hornblendic or pyroxenic asbestos. The mineral of Alp Quadrata is commercially valuable, very flexible, long-fibred, silvery-white, or else greyish-brown and yellowish in colour. Some of the fibres reach 2 feet in length. They are, however, deficient in lustre and look like weather-beaten timber. The usual length of the fibres varies between 4 and 8 inches, and the thickness of the deposit is anything between a mere papery film coating the serpentine-rock and a layer 5 inches thick. There occur, however, in places, positive masses of asbestos-rock, wherein the fibres are not so well developed. If allowed to weather on the mine-heap for a time, these masses become suitable (as a second-rate quality) for industrial purposes. The distribution of the asbestos in the matrix is very irregular: sometimes it has been found close to the outcrop, sometimes payable quantities have only been got by working pretty deep down. The asbestos-deposits follow all the contortions and nip-outs, and irregularities of the slaty serpentine.

Six mines were opened up on these deposits, and appear to have all been worked out in 1880; yet the author evidently thinks that mining operations

could be resumed with advantage in some, at any rate, of these. He estimates that the output from the best localities would average 2 to 3 per cent. (of raw asbestos) of the quantity of rock mined. This used to be considered sufficient in the Canadian asbestos-mines, but improved appliances and methods of working have brought the percentages there up to 6, 10 and 15. A Zurich firm obtained in 1901 a concession for re-starting asbestos-mining near Poschiavo, and set about 15 men to work, but no information is yet available as to the results obtained. The author gives reasons for considering the Italian asbestos vastly superior in quality to the Canadian. L. L. B.

THE AGE OF THE TONGKING COAL-DEPOSITS.

Note sur la Flore Fossile du Tonkin. By R. ZEILLER. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 498-501.

The abundant specimens of ferns, horsetails, cycads, etc., recently submitted to the author from the mines of Ke-Bao, Hong-Gay, etc., as well as the discovery of an ammonite, amply confirm the conclusion at which he arrived as long ago as 1882 (but then only on the faith of a few specimens), that the coals worked there are of Rhætic age. The lithological facies of the rocks had induced some geologists to refer them (erroneously, as it now appears) to the Carboniferous system.

Besides these coal-deposits of Lower Tongking, it may be remembered that coal also occurs on the Upper Red river, at Yen-Baï, where it was discovered a few years ago. So far as can be ascertained from the plant-remains found in it, and the associated freshwater mollusca, it is of Middle or Upper Tertiary age. L. L. B.

THE MINERAL WEALTH OF BUKHARA AND TURKESTAN, CENTRAL ASIA.

Notice géologique sur les Richesses Minérales de la Boukharie et du Turkestan. By E. D. LEVAT. *Bulletin de la Société Géologique de France*, 1902, *series* 4, *vol. ii.*, *pages* 439-455, *with* 7 *figures in the text and* 1 *plate.*

The author went on a four months' journey, in the first half of 1902, into Central Asia on behalf of the French Government, and unusual facilities were therefore placed at his disposal by the Russian authorities.

Starting from Charjui on the Amu Daria, the author proceeded up that river to the present terminus of steam-navigation, the intrenched camp of Patta Gissar. Landing there, and noting by the way the occurrence of saliferous marls alternating with gypsum-beds, all of Cretaceous age, he followed the river-bank up to Saraï. Turning thence abruptly northward, he soon left behind the great lœss-formation (Quaternary æolian drift) which fringes the Amu-Daria plain, and entered upon an area of Tertiary grits. These gradually pass into enormous masses of gold-bearing conglomerates, the pebbles of which are chiefly derived from diorites and other crystalline rocks. He regards them as being largely of glacial origin, and estimates their total thickness at 5,000 feet. The gold occurs in the form of flakes, generally of small dimensions: nuggets weighing from ½ ounce to 1 ounce Troy are of rare occurrence. The natives have worked out thoroughly all the deposits above water-level along the river-valleys, and even by the most approved modern methods there is no hope of making a

profit out of the tailings that they have left. Below the river-level, rich deposits remain to be worked, and workings have been started of late years in the Safet-Daria valley, for instance, where the gold disseminated in the conglomerates is found concentrated in pay-gravels some 55 feet thick, which are richest near the bed-rock. The flat form, characteristic in Eastern Bukhara, of the gold-flakes has favoured their transportation for considerable distances along the watercourses. The mass to be worked through is so enormous, that modern plant (such as excavators and dredges) must be used to ensure a profit. Moreover, native labourers, although working at a low wage now, will prove, as experience in Turkestan has shown, much more exacting so soon as they perceive that there is a demand for them. They cannot be depended on to stay at the mines when the season for sowing or the season of harvest arrives, but desert the mines *en masse* whatever offers may be made to them. There are no roads fit for wheel-traffic in Eastern Bukhara, and machinery will have to be brought in, piece by piece, on camel-back.

Passing up from Tabi Dara to the mountain-range named after Peter the Great, the barren grits, etc., of the Lower Eocene are seen to succeed the gold-bearing conglomerates. Reddish marls begin to alternate with the grits, contortions and reversed folds make their appearance in the strata, and indicate that one is approaching the Cretaceous *massif* which closes in the old Tertiary basin. Here again red and green marls alternate with beds of gypsum and rock-salt. The latter mineral is worked at Sagri Dach.

The great Alaï range, with its high peaks and glaciers, is made up of crystalline rocks (gneisses, granites, mica-schists), and crossing this with some difficulty, as the ordinary passes were blocked by the breakdown of bridges, the author reached again the Cretaceous formations in the Sir-Daria basin. Red limestones overlie black shales with outcrops of lignite. At Usht-Kurgan, a coal-seam in the Cretaceous marls is worked: inclusive of partings it is 65 feet thick. The coal-contains 45 per cent. of volatile substances. Near Khokand and Namangan in Ferganah, and also near Merv, borings have been put down for petroleum, and occurrences of ozokerite are recorded from several localities in Bukhara and Turkestan. The natives have obtained petroleum by digging comparatively shallow wells, and always in the neighbourhood of the great mountain-ranges against which the Cretaceous and Tertiary sedimentaries abut.

Numerous outcrops of brown coal and some few of copper and lead-ores are indicated on the author's map. The naphtha and ozokerite-deposits are of Cretaceous age; the brown coal is in some cases Cretaceous, in others Tertiary; and the gold-bearing conglomerates are Upper Eocene.

L. L. B.

THE MINERAL RESOURCES OF THE NORTH-EASTERN ALTAI, (SIBERIA).

Description géologique de la Partie Nord-ouest de la 15me Feuille de Zone VIII. et de la Partie Sud-ouest de la 15me Feuille de Zone VII. de la Carte Générale du Gouvernement de Tomsk (Feuilles Borissovo et Béresovka). By B. K. Polienov. *Travaux de la Section géologique du Cabinet de sa Majesté*, 1901, *vol. iii., pages* 133-341.

This elaborate memoir is in Russian, and therefore is a sealed book to a large number of possible readers. It is accompanied by a summary in French, whence the following comparatively meagre details may be gleaned.

The region covered by the sheets of Borissovo and Berezovka of the Imperial survey-map is the north-eastern portion of the province of the Altai. It is cut in two by the river-valley of the Tomi; the south-western half, a level steppe, is chiefly made up of clays and grits correlated with the coal-bearing strata of the Kuznetsk basin, while the north-eastern half is formed by the mountain-slopes of the Alatáu. These slopes are largely made up of Devonian rocks resting against the granites, syenites, gneisses and schists of the main Alatáu range. The Carboniferous strata of the south-western steppe rest conformably upon these Devonian rocks. The Lower Carboniferous is represented by limestones containing a fauna comparable with the Tournaysien and (in part) the Voulsortien of Belgium. It is succeeded by grits, conglomerates and shales, with the last-named of which coal-seams are interbedded and also bands and concretions of sphærosiderite. Prof. Zeiller considers that the plant-remains found in this series are analogous to those characteristic of the Stéphanien of Western Europe. The Kuznetsk group of Coal-measures is immediately overlain by post-Tertiary deposits: loams, sand, lœss and alluvium.

The region appears to have been one of extreme vulcanicity in Devonian times, but there was no volcanic activity during the deposition of the basement Carboniferous. In the Coal-measure period, however, eruptions began again, and molten melaphyres invaded the coal-bearing grits. The coal-deposits have not been worked, so far. In the basin of the Inia river, many scores of coal-outcrops may be counted; the mineral is of excellent quality, the seams are in many cases from 6 to 16 feet thick, and their dip is variable, from *nil* to 60 degrees.

Besides the sphærosiderite already mentioned, deposits of brown hæmatite have been found, also grindstones and honestones, white porcelain-clays, etc. Practically all the most productive gold-placers have been worked out. The precious metal occurs in the alluvium of a great number of the streams which come down from the Alatáu mountains. However, as the actual primary matrix of the gold, the original quartz-reefs (?) remain undiscovered, the gold-mining industry in this area is in a moribund condition.

L. L. B.

COPPER-BEARING VEINS IN TRANSBAIKALIA, SIBERIA.

Die zeolithische Kupfererzformation in Transbaikalien. *By* R. BECK. *Zeitschrift für praktische Geologie*, 1901, *vol. ix.*, *page* 391.

German prospectors have found, in the Chida river-basin in Transbaikalia, what appears to be an industrially-important cupriferous deposit. Amygdaloidal melaphyres, with opaline amygdules, are traversed by veins containing native copper in masses weighing as much as 2¼ pounds, and native silver. This is correlated with the occurrence of native copper sprinkled among zeolites and calcite, recorded two years ago from Transbaikalia.

Concessions have been obtained by the same syndicate, for working argentiferous lead-ores among the crystalline schists, and these have a ferruginous gossan highly charged with gold; also for working graphite-deposits and extensive coal-fields in the district of Naryn. Detailed communications regarding all these occurrences are foreshadowed.

L. L. B.

THE AURIFEROUS REGION OF SIBERIA.

Explorations géologiques dans les Regions Aurifères de la Sibérie. [OFFICIAL.] *Comité géologique, St. Petersburg,* **1900-1901, 324** *pages, and* 7 *maps.*

The elaborate monographs here summarized deal with the Lena, Yenisei, and Amur river-basins; and doubtless the Russian Government purposes to publish further reports on the same scale, dealing with the other gold-bearing districts of Siberia: as, however, the monographs are not numbered consecutively, it is difficult to say where the series begins or where it will end. Of its scientific and industrial value there can be no question.

Mr. A. P. Gerasimov describes the results of detailed investigations made by him in the course of 1900 in the Vacha and Kadali river-basins in the mining district of the Lena. The region is a mountainous one, and is largely made up of pre-Cambrian and Cambrian metamorphic rocks covered by an immense thickness (280 feet) of river-gravels and Glacial Drift. At the base of these alluvial and Glacial deposits, immediately overlying the ancient rocks, is an auriferous stratum, varying in thickness from 2¼ to 5 feet, and containing from 4 to 67 parts of gold per million. Thus, the rich placers lie at considerable depths below the surface, and are of pre-Glacial age; but there are also shallow and comparatively poor post-Glacial placers. The Olekma schists are traversed by numerous quartz-veins, which, on the whole, are extremely poor in gold, not to say quite barren of it. Consequently, they cannot be regarded as the original matrix of the gold now found in the placers. On the other hand, the author observes that these same schists are very rich in pyrites, and a specimen of pyrites from the Konstantinovsky placer was found to contain as much as 1,582 parts of gold per million. Whence perhaps it is permissible to infer that the placer-gold was really derived from the pyritiferous schists.

Mr. L. Yachevski deals with the Teya and Enashimo river-basins, in the Northern Yenisei region. Here the most ancient rocks are gneisses and mica-schists, overlain by three successive series of sedimentary origin, with unconformities between each of them. Gold occurs in quartz-veins in the lowermost of the three; it is found dispersed through the shales of the middle series; and it occurs in the red basement-grits and conglomerates of the uppermost series. Moreover, auriferous breccias have been observed in the neighbourhood of faults. But in the area here described the attention of gold-miners has been concentrated chiefly on the auriferous alluvia which are, of course, of immensely more recent date than any of the rocks just mentioned. These alluvial deposits have also yielded diamonds along the Melnichnaya and Tochilny creeks.

Mr. N. Izhitski has examined the Penchenga, Ishimba and Gorbilsk river-basins, in the Southern Yenisei region, and finds that (geologically speaking) the district is of very uniform character. It comprises three great groups of rocks:— (1) The massive crystallines, (2) the metamorphic schists, and (3) the shales, grits and limestones, all folded in a general north-westerly direction. Productive gold-placers are numerous, but mining-industry is at a low ebb, owing to the scarcity of men who combine sound knowledge with a spirit of energy and enterprise.

Mr. A. Meister deals with the Uderei and Udoronga river-basins, also in the Southern Yenisei region. Here too are massive crystalline, metamorphic and sedimentary rocks all folded in a north-westerly direction. Two systems of quartz-veins, crossing each other at right angles, occur, and some of them are auriferous. The author divides the placers of the

district into three groups:—(1) Recent alluvial, in the river-beds—by far the most numerous; (2) ancient terrace-placers; and (3) deep lying terrace-placers, as much as 80 feet down. Some of the shales in the sedimentary rock-group are gold-bearing.

In another memoir, the same author describes his researches in the river-basins of the Great and Little Murozhnaya, the Chernaya, and the Rybnaya. These have led him to the conclusion that the placer-gold there is derived in part from quartz-veins, in part from shales and limestones. The intrusive rocks (diabases and diorites) have played a purely passive part in the enrichment of the rocks. On the other hand, this enrichment is genetically associated with the phenomena of faulting and dislocation.

Messrs. P. K. Yavorovsky and M. M. Ivanov studied the Zeya river-basin in the Amur region, with the following results:—They found a granite-massif overlain by Archæan gneisses (the predominant rocks of the area), Jurassic sedimentaries, and post-Pliocene and recent fluviatile deposits. The area has been intensely folded, and the richness in gold of the placers is intimately connected with the configuration of the folds. Thus the placers near the Ilikan anticline are much richer than those which lie within the radius of the Brianta anticline, where the gold-particles have undergone deformation and pulverization. The precious metal occurs in nearly all the rocks of the gneissose group, but is absent in the Archæan granite and in the diabases and porphyrites which border the Jurassic basin. The quartz-veins are usually very poor in gold, but are productive at the few points where they intersect the post-Jurassic pegmatites and the hornblendites. It is noticeable that those alluvial deposits which strike east and west, parallel with the auriferous bed-rocks, are richer than those which strike north and south across those rocks. The placer-industry promises well, but the prospects of gold-mining in the solid rocks are not hopeful. L. L. B.

MAGNETITE-DEPOSITS IN WESTERN SIBERIA.

Die Magneteisenerzlagerstätten der Hütte "Nikolajewski Zawod" im Gouv. Irkuck (Westsibirien). By TH. VON GÓRECKI. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 148-155, *with* 6 *figures in the text.*

The Nikolayevski ironworks, at a standstill for the last four years or thereabouts, belonged to a limited company within whose domain (255 square miles) lay magnificent timber-forests, as well as the magnetite-deposits about to be described. This "little principality," as the author terms it, is situated in the Nizhnye-Udinsk district of the Government of Irkutsk. Water-communication with the city of Irkutsk (420 miles distant by river) is secured by means of the Dolonovka, a sub-tributary of the Angara. The nearest railway-station (Tulun) is some 132 miles away. In 1899, no less than 1,700 persons were employed on the estate, and without reckoning steel-rails, the weight of material sold was 4,545 tons. Three blast-furnaces were at work, on ores chiefly obtained from the Yermakovski mine. The other three mines belonging to the company were known as the Dolonovski, Keshemski and Krasnoyarski mines respectively.

The Dolonovski was the first iron-ore deposit to be discovered in that region. Here quartzitic Devonian sandstones have been highly altered by contact-metamorphism. Indeed, they are described as presenting a slaggy

appearance, due to the eruption of a rock belonging to the group of the olivine-diabases and known as "Siberian trap." This "trap" occurs in more or less extensive sheets over a considerable area, from the Oka river-basin to that of the Kan. With this trap is associated on the Dolonovski hill a porphyrite containing innumerable glass-inclusions, and finally tuffs and breccias, amid which is magnetite occurring in bands 10 inches or so thick, alternating with bands of calcite and quartz. The total thickness of the ore-deposit does not probably exceed 10 feet, but sometimes the entire thickness consists of magnetite without any bands of calcite or quartz. Opencast workings were carried down to a maximum depth of 65 feet, and the deposit was seen to continue deeper still. It may be regarded as consisting of two great reefs, which apparently cut each other at a rather wide angle. The author is inclined to recommend further exploration-work, and points out that the average analysis of the ore shows 58·3 per cent. of metallic iron. It contains 0·44 per cent. of phosphorus, and 3·3 per cent. of silica.

The rocks in the neighbourhood of, and forming, the Yermakovski hill (1,770 feet above sea-level) are of much the same character as those just described. The ore-deposits here attain a maximum thickness of 25 feet or so, and four distinct reefs are traced, three of which cross the main one at various angles. Analyses show the ore to yield 65·23 per cent. of metallic iron. Phosphorus is apparently absent, and the percentage of silica is 2·03.

In both mines, the magnetite is intimately associated with volcanic tuffs and secondary breccias—and the author traces a more immediate connection between the ore-deposit and these clastic rocks than between it and the outpourings of Siberian trap and the associated augite-porphyrite.

Some 30 miles farther north is the Krasnoyarski deposit, of comparatively recent discovery. Here again the ores are banded, with intercalated calcites, and the maximum thickness of the ore-body revealed by the opencast workings exceeds 13 feet. The "vein" strikes 115 degrees north-west, and pitches south-westward 75 degrees. The country-rock is a breccia of vitreous fragments cemented together by calcspar, magnetite, chlorite and zeolites. The average chemical analysis of the ore shows 55·99 per cent. of metallic iron, 5·69 per cent. of silica, but no phosphorus or lime.

About 20 miles away to the north-east of the Krasnoyarski mine lies that of Keshemski Rudnik, considered of sufficient importance to have warranted the laying out in its neighbourhood of the ironworks known as the New Nikolayevski Zavod. (The Old Nikolayevski Zavod is situated near the Dolonovski mine.) Here only one very thin band of calcite occurs in the ore-body, which consists of a maximum thickness of 15 feet of nearly pure magnetite. The country-rock is again a breccia of volcanic fragments cemented largely by magnetite, which yields place to calcite and chlorite as the distance from the ore-body increases. On analysis the ore yields 61·72 per cent. of metallic iron, 3·97 per cent. of silica, but neither phosphorus nor lime.

The genesis of these rich ore-deposits is discussed in detail, and the author ranges them among the epigenetic variety, that is, ores which may be regarded as infillings of fissures and cavities. He compares them with the deposits of Traversella in Piedmont and Calamita in Elba, and considers that they were precipitated from thermal waters, which represented the moribund stage of vulcanicity in this area. The veins may be truly termed

"infiltration-veins," and fine pseudomorphs of magnetite after hæmatite have been observed in the Keshemski mine, for instance.

It may be predicted that the completion of the great Siberian railway will probably give rise to renewed mining activity in this now less-remote region of Western Siberia. L. L. B.

PHOSPHATIC, ASPHALTIC, AND PETROLEUM-DEPOSITS IN PALESTINE AND EGYPT.

Über das Vorkommen von Phosphaten, Asphaltkalk, Asphalt und Petroleum in Palästina und Ägypten. By DR. M. BLANCKENHORN. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 294-298, *with* 1 *figure in the text.*

Within recent years, the Campanian or Middle Senonian (Cretaceous) limestones of Palestine have been found to contain rich deposits of phosphate, besides the bitumen which occurs in some of the limestone in payable quantity. It may be noted, by the way, that the phosphate-deposits of Algeria and Tunisia are found at a higher horizon, in Lower Eocene or Suessonian beds, which are barren in Palestine.

Phosphates of the same age as those discovered by the author in Palestine in 1894 were found in 1897-1899 by the officers of the Egyptian Geological Survey at several remotely-situated localities in Egypt, but he considers those of Palestine as in part of better quality and much more favourably placed from the industrial point of view.

He mentions an exposure on the high plateau of the Eastern Jordan region, about 3,000 feet above sea-level, yielding a phosphate of the following composition: phosphorus pentoxide, 36 per cent.; lime, 53 per cent.; alumina and iron sesquioxide, 1·12 per cent.; calcium fluoride, 9·8 per cent.; calcium sulphate, 1·86 per cent.; and insoluble residue, 0·46 per cent. At a locality known to the author in Judæa, within a thickness of 23 feet there are three bands of phosphate, respectively 20 inches, 40 inches and 45 inches thick, yielding a mineral which contains from 45 to 50 per cent. of tribasic phosphate of lime, 43 per cent. of carbonate of lime, about 2·5 per cent. of alumina and iron oxides, and 3 per cent. of silica. The cost of working the Palestinian phosphates would be very small, for reasons which are indicated.

The deposits described by the Egyptian Survey occur in Sinai, in the Arabian Desert (about 7 miles from the Red Sea), west of the Duwi range (31 miles north-west of Qosseir), also north-east of Qeneh, 6 miles from Qift or Quft railway-station, and lastly in the Dahla oasis of the Libyan Desert. The bituminous or asphaltic limestones associated with the calcareous phosphates of Palestine occur in "inexhaustible quantity" along a belt parallel to the Dead Sea and the Jordan valley. At Nebi Musa, the percentage of bitumen in the rock attains a maximum of 25. The author believes that the mineral will be found very suitable for street-paving purposes, and experiments to that end are shortly to be made in Berlin.

The asphalt of the Dead Sea region fetches high prices on the world's markets, and yet no systematic working of it on a large scale has yet been attempted.

Of greater importance even than the deposits already mentioned for the future of Palestine would be the development of the petroleum-industry. Theoretically, it seems to the author more than probable that borings put down on the eastern and western shores of the Dead Sea would strike

oil: the stratigraphical, mineralogical, chemical and climatic conditions of the region all point to successful prospecting for petroleum. Oil oozes out at the surface of the ground at several points, and the author describes one spring, the locality of which is at present only known to himself and a few of his fellow-countrymen.

The petroleum of Gebel Sĕt on the Gulf of Suez appears to be of much later age than, and of an entirely different origin from, that of the petroleum of the Dead Sea area. Nor does it appear that borings in the neighbourhood of Gebel Sĕt are ever likely to yield oil in payable quantity.

The paper generally is intended to call the attention of German capitalists to Palestine, more especially than to Egypt, as a field of future mining enterprise.

L. L. B.

THE COAL-FIELD OF HERAKLEA, ASIA MINOR.

Das Steinkohlenbecken von Heraklea in Kleinasien. By BRUNO SIMMERSBACH. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 169-192, *with* 12 *figures in the text.*

This coal-field is situated in the north-western portion of Asia Minor, very near to the coast of the Black Sea, from which in places it is barely more than ½ mile distant. The seams are numerous, often very thick, and furnish a coal which is variously compared by experts to Cardiff and to Newcastle coal. The coal-bearing belt, some 3¾ miles wide, extends for 93 miles from south-west to north-east, but the total annual output so far only averages 160,000 tons, whence it may be inferred that an enormous area is still practically untouched

The author follows Mr. G. Ralli in subdividing the Heraklean coal-formation into three stages:—(1) The lower, or that of Alaja-Agzi; (2) the middle, or that of Koslu; and (3) the upper, or that of Karadon. The lithological facies resembles that of most European coal-fields, the strata consisting mainly of various sandstones, generally light-coloured, and fossiliferous carbonaceous shales. It is already demonstrable that a large number of excellent coal-seams continue the whole length of the belt, from Heraklea to Amasra. In the Koslu group, for instance, are six important seams, the thinnest of which is 6 feet thick, while the others range from 10 to 13 feet. Almost everywhere the seams strike north-east and south-west, with a moderate dip, varying between 10 and 12 degrees, although occasionally this steepens to the vertical.

It has been found that, on long sea-voyages, the Heraklean coal, which is very light and burns with a long flame, deteriorates in quality; but the results of the experiments made with it by various foreign fleets (especially the French) have not given rise to any complaint. It would also appear that the coal improves in quality the farther inland that it is worked; and that portion of the field which lies farther south, away from the Black Sea, has not yet been worked.

A series of ten chemical analyses shows the percentage of carbon to vary from 51 to 64, that of volatile matter from 27·6 to 45, and that of ash from 4 to 11·4. But all these samples were taken from the actual outcrops, and do not fairly represent the quality of the perfectly-fresh mineral got from below the surface.

Entering then into greater detail, the author describes the Alaja-Agzi or lowermost group, called after the locality of that name, where at least

nine seams of a total thickness of 37½ feet have been proved. The thickness of strata intervening between the top seam and the bottom one is estimated at about 650 feet. The bottom seam thins out close to the seashore. How much deeper down coal may yet be struck is not yet known, but for various reasons the presence of lower seams yet at Alaja Agzi is shown to be probable. The seams here strike generally east and west, with a southerly dip of 15 to 30 degrees. Farther east, at Kirechlik, four seams have been proved exceeding 3¼ feet in thickness respectively, and other thinner seams are known. They dip as much as 80 degrees southward, and strike north—70 degrees—east, that is nearly across the general strike of the Alaja-Agzi district. They are not found at that locality itself, nor at Teflenti: they lie, in fact, much deeper than the known seams of those areas, which again recur in the little valley of Kirenlik. Seven analyses of coal from the lower group are tabulated: the percentage of ash varies from 2 to 9·75; that of hygroscopic water from 1·5 to 2·75; that of volatile substances from 35·4 to 42·8; and that of coke produced, from 57·2 to 64·6. In three samples, the coke was porous and tumescent; in five samples the ash was brown and in one yellowish-brown. At this stage, one disadvantage of the Heraklean coal is mentioned—its proneness to evolve great clouds of black smoke when used for boiler-firing, etc. No experiments have been made with it in regard to the production of gas for illuminating purposes, but the author thinks it especially suitable for such purposes. The mineral is usually somewhat hard, and yields a brown streak. The higher lying seams of the Alaja-Agzi group contain a smaller percentage of volatile substances than the lower lying ones, in contradistinction to the usual experience in coal-fields. Evidence is adduced to show that the geological age of the group is that of the Upper Kulm.

Coming now to the middle group, we learn that exploration-work has been pushed forward at Koslu and in the neighbouring valleys more than anywhere else in the coal-field, and an enormous number of seams have been proved. The boundaries of this portion of the coal-field, so far as at present known, are formed by two great faults, a northern fault and a southern: the coal-outcrop has been traced for a distance of 12½ miles along one of these. On the western slopes of the Uzulmez range, in the neighbourhood of the State Railway, coal-seams have been worked since 1854 without showing signs of exhaustion. The Mulazim seam, 6½ feet thick, of pure coal, is one of those that are as yet practically untouched. The author tabulates, after Prof. Ralli, 54 analyses of coal from the Koslu group. These show percentages of ash varying from 2·5 to 13·25; hygroscopic water from 0·75 to 2·5; volatile substances from 28·5 to 39·8; coke produced, from 59·7 to 71·5. On the whole, the mineral may be regarded as an exceptionally superior quality of gas-coal. The author himself adds numerous other analyses, the results of which are sensibly identical with the foregoing. The palæontological evidence has shown that the Koslu group occupies an intermediate position between the lower and middle stages of the Westphalian Coal-measures.

The Karadon or Upper group may be regarded as divided from the middle group by a mass of conglomerate some 330 feet thick, the dip of which gradually increases in steepness until it reaches the vertical at the great southern fault. On the further side of that appear the first coal-seams of the Karadon group, and their fossils show them to belong to the lowermost portion of the true Upper Coal-measures. Four main seams in this group are known,

pretty close together, and varying each in thickness from 3 to 5 feet or so. The author tabulates 16 analyses, wherein the percentage of ash varies from 2·5 to 12·25; that of hygroscopic water from 1 to 6·5 (exceptional); that of volatile substances from 29 to 52·6; and that of coke from 47·4 to 71. The ash has a generally characteristic pale-grey colour.

The Amasra district forms the easternmost extremity of the Heraklea coal-field, so far as at present known. Here at least five coal-seams have been proved, varying respectively in thickness from 3 to 8 feet or so. The average percentage of three analyses is as follows:—Ash, 6·05; hygroscopic water, 6·1; volatile substances, 39·2; coke produced, 60·7.

Among the obstacles which stand in the way of the full development of this magnificent coal-field, are the inherent apathy and conservatism of the Turks, and the unreliability of the labouring classes, who will only work uninterruptedly for a fortnight or so at the mines, and then go back to their native villages, careless whether others are ready to take their places or not.

The paper is illustrated by a map and detailed vertical sections of the coal-seams. L. L. B.

METALLIFEROUS ORE- AND COAL-OCCURRENCES IN SOUTH-EASTERN ASIA MINOR.

Geologische Studien im Südöstlichen Kleinasien. By DR. FRANZ SCHAFFER. *Sitzungsberichte der Mathematisch-naturwissenshaftlichen Classe der kaiserlichen Akademie der Wissenschaften [Vienna]*, 1900, *vol. cix., abtheilung I., pages* 498-525, *with 2 maps in the text.*

From this account of a journey of natural-history exploration undertaken by the author in Cilicia and Cappadocia in the spring of 1900, the following references to ore-deposits, etc., may be extracted. (He points out in the first place that, even now, the region is from the geological point of view but little known.)

The serpentine which underlies the Miocene limestones near the head-waters of the Sunturaz-Chai contains chrome-iron-ore at Kairak-Keslik. Farther north, in the Allah-Dagh are veins of hæmatite.

Journeying from Tarsus, along the course of the Chakyt-Chai, up towards the Cilician Gates (πυλαὶ κιλικίης), older Tertiary limestones are met with at Koerli, containing iron-ores.

At Aiwabé-Han, in the river-bed of the Aiwabé, occur thin seams of a deep black "brown coal," with a pitchy lustre. This occurrence, however, is not considered to be of industrial importance. The coal-bearing marls are traced for 6 miles or more as far as Bozanti, and at Belemedyk (on the middle course of the Chakyt-Chai) they contain rather thicker seams.

The grey freshwater marls on the plateau between Nemrun and Zibil contain thick seams of "brown coal"; the author estimated a workable thickness of 5 feet. The coal is of a lustrous black, very brittle, laminated, and after some exposure to the atmospheric agencies disintegrates into a crumbly mass. Although the lie of the seams is much disturbed, there is reason to believe that they extend over a considerable area. They are probably of the same age as those of the Aiwabé valley, and one may conclude that there is a continuous belt of these older Tertiary land- and fresh-water-formations along the base of the main mountain-range from Zibil up to the Ak-Dagh. Similar coal-bearing marls are also found at Kara-Sis.

L. L. B.

THE MINERAL RESOURCES OF THE PORTUGUESE COLONIES.

As nossas Riquezas Coloniaes. By José de Macedo. *Boletin da Sociedade de Geographia de Lisboa*, 1901 [1900], *series* 18, *pages* 411-610.

The fourth chapter of this exhaustive memoir on the oversea possessions of Portugal gives in some 22 pages a compilation of all the available facts and opinions (more or less speculative) in regard to their mineral wealth. Concerning ourselves with the facts alone, we note in the first place that trustworthy scientific information as to these Portuguese colonies is somewhat scanty. The Cape Verde Islands, for instance, "are said to contain" deposits of iron- and copper-ores, silver- and gold-bearing ores, native sulphur, etc. Ferruginous springs are abundant there; salt has been exported in large quantities from Bōa Vista and the Ilha do Sal, but the author gives no clear explanation as to how the salt is got.

In Portuguese Guinea are petroleum-springs, as yet, untapped. Gold is, of course, the best-known mineral product of that region; nothing positive can be stated as to other metals there. In San Thomé and Principe there are deposits of mercury and manganese-ores, rock-salt, petroleum, etc.

Angola has long been known as possessing considerable mineral resources, among which are the coal, rock-salt, hæmatite and copper-ores of Mossamedes, etc., the magnetite of Gambos, and the native sulphur of Benguella. Petroleum of excellent quality occurs, chiefly in the Dondo district.

Turning then to East Africa, the author is unable entirely to resist the temptation which besets most of those who have lately written on that part of the world, to share in the controversy regarding the original site of the land of Ophir. He appears to think that it embraced most of the country northward from the Cape up, and including Mozambique.

Concerning Mozambique, it is pointed out that in 1899 the following mining concessions were granted:—6 for working coal, and 10 for working copper- and silver-ores, gold- and diamond-reefs. At present 61 mining concessions are in force in the province. That part of Manicaland which has remained Portuguese territory is "incomparably richer" in gold, silver, copper, iron, etc., than the portion which now belongs to the British Empire; and it is asserted that a certain gold-mine in Portuguese Manicaland obtains yields which are superior to anything ever got in the Transvaal. The districts of Lourenço Marques and Cabo Delgado are also said to be rich in coal and other minerals.

The little Portuguese possessions in India contain coal, iron- and copper-ores, but not in sufficient quantity to found a great industry upon them. In the island of Timor, five petroleum-springs are known on the southern coast, in close proximity one to the other. There is also native sulphur of excellent quality, coal, a little gold, iron-, copper- and silver-ores.

L. L. B.

THE BORACIC DEPOSITS OF THE SALINAS GRANDES, ARGENTINA.

Gisements de Borate des "Salinas Grandes" de la République Argentine. By H. Buttgenbach. *Annales de la Société géologique de Belgique*, 1901, *vol. xxviii., Mémoires, pages* 99-116, *with* 4 *figures in the text.*

The Salinas Grandes are vast salt-marshes, situated on a high desert-plateau in the region where the frontiers of Argentina march with those of Chile and Bolivia. They are bounded on the east and on the west by lofty

snow-capped mountain-ranges, and they are in 23 degrees south latitude and 68 degrees west longitude of the meridian of Paris.

In the centre of these basin-like marshes, the ground is perfectly flat, and is covered by a deposit of rock-salt which reaches a maximum thickness of 13 inches or so. The water which floods these marshes from December to March runs off or percolates through them very rapidly, and they dry up quickly, thanks to the generally high temperature of the air during the daytime, thanks also to the action of the winds which sweep resistless across the plateau. Vegetation is of the scantiest description—mere desert-scrub, and sand-storms are frequent.

The upper portion of the rock-salt bed is grey, but the lower portion is white, very pure, with good cleavage. It is got out in blocks, the sides of which measure about 16 inches, and finds a ready market in the neighbouring provinces of Salta and Jujuy. The salt-bed diminishes in thickness from the centre of the basin towards the periphery, and where it dies out the borate-deposits come in: these are now being worked, for the most part by the International Borax Company.

The mineral is a hydrated borate of lime and soda, containing a little magnesia, calcium carbonate and sodium sulphate, and highly impregnated with common salt, the elimination of which, however, is easy. The author discusses in some detail the question as to the exact species to which the mineral can be referred, and finally decides in favour of ulexite, the chemical formula of which is $Ca_2Na_2Bo_{10}O_{18}(H_2O)_{16}$. Moreover, the results of a crystallographic examination under the microscope point in the same direction, the distinctive characters of ulexite being very marked.

This ulexite of Salines Grandes occurs in nodules which, from their resemblance in form to potatoes, are called *papas* by the workmen. As a rule, they are about the size of a man's fist, but are sometimes as big as a child's head. They are agglomerated together into beds varying from 4 to 28 inches in thickness, and lie in a matrix which varies from a slightly clayey loam to a sticky clay. This boracic deposit is never found at a greater depth than 5 feet below the surface, and rests upon a barren bluish clay of unknown thickness. There appears to be no sort of regularity in the number, thickness, or relative position of the masses of borate within the limits just indicated, and on the whole the deposit is fairly comparable with that of Columbus Marsh in California.

When the boracic nodules are dug out they are damp, plastic, and highly saline. If left exposed, however, to the sun and air for not less than 5 and not more than 20 days they become hard, lose about 20 per cent. of their weight, and when they are shaken up in a basket the earthy matter clinging to them crumbles away. They then contain at most 2 per cent. of common salt. Sometimes the nodules are cemented together by (and impregnated with) a hard material called *caliche* by the workmen: this consists largely of sodium nitrate, gypsum, glauberite, pickeringite and rock-salt.

The author discusses in some detail the various explanations that can be given to account for the origin of these deposits, and points out that the intervention of volcanic phenomena is, in any case, necessary to account for the presence of boric acid. Further, he believes that the formation of ulexite-nodules is still going on, and that this formation is conditioned by the annual flooding of the marshes during the rainy season.

L. L. B.

II.—REPORT OF THE CORRESPONDING SOCIETIES' COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BELFAST, 1902.*

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The following Corresponding Societies nominated delegates to represent them at the Conferences:—The Institution of Mining Engineers, Prof. Henry Louis; the Midland Counties Institution of Engineers, Prof. Henry Louis; Midland Institute of Mining, Civil and Mechanical Engineers, Mr. James Barrowman; the North of England Institute of Mining and Mechanical Engineers, Mr. J. H. Merivale; The Mining Institute of Scotland, Mr. James Barrowman; and the South Staffordshire and East Worcestershire Institute of Mining Engineers, Prof. Henry Louis.

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First Conference, September 11th, 1902.

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Second Conference, September 16th, 1902.

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Mr. Mark Barr attended as a representative of Section G (Engineering) and called attention to the Committee for Investigating the Resistance of Road-vehicles to Traction.

Committees appointed by the General Committee at the Belfast Meeting in September, 1902.

1.—Not receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman and Secretary.*—Prof. J. D. Everett. Lord Kelvin, Sir Archibald Geikie, Mr. James Glaisher, Prof. Edward Hull, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr A. Strahan, Prof. Michie Smith, Prof. H. L. Callendar and Mr. B. H. Brough.
The nature of alloys.	*Chairman and Secretary.*—Mr. F. H. Neville. Mr. C. T. Heycock and Mr. E. H. Griffiths
To consider the best methods for the registration of all type-specimens of fossils in the British Isles, and to report on the same.	*Chairman*—Dr. H. Woodward. *Secretary*—Mr. A. Smith Woodward. Rev G. F. Whidborne, Mr. R. Kidston, Prof. H. G. Seeley, Mr. H. Woods and Rev. J. F. Blake.
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2.—Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.	Grants. £ s. d.
Seismological observations	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Prof. J. Milne. Lord Kelvin, Prof. T. G. Bonney, Mr. C. V. Boys, Prof. G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Dr. R. T. Glazebrook, Prof. C. G. Knott, Prof. R. Meldola, Mr. R. D. Oldham, Prof. J. Perry, Mr. W. E. Plummer, Prof. J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson and Prof. H. H. Turner.	40 0 0
To co-operate with the Committee of the Falmouth Observatory in their magnetic observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. R. T. Glazebrook. Prof. W. G. Adams, Captain Creak, Mr. W. F. Fox, Prof. A. Schuster and Sir A. W. Rücker.	40 0 0
To investigate the erratic blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Prof. P. F. Kendall. Prof. T. G. Bonney, Mr. C. E. De Rance, Prof. W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker and Mr. F. W. Harmer.	10 0 0
The movements of underground waters of north-west Yorkshire.	*Chairman.*—Prof. W. W. Watts. *Secretary.*—Mr. A. R. Dwerryhouse. Prof. A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. G. Bray, Mr. W. Lower Carter, Mr. T. Fairley, Mr. P. F. Kendall and Mr. J. E. Marr.	40 0 0
To study life-zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Prof. E. J. Garwood, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Prof. G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan and Dr. H. Woodward.	5 0 0
The collection, preservation and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Prof. T. G. Bonney, Dr. T. Anderson, Prof. E. J. Garwood, Prof. S. H Reynolds, Mr. A. S. Reid, Mr. W. Gray, Mr. H. B. Woodward, Mr. R. Kidston, Mr. J. J. H. Teall, Mr. J. G. Goodchild, Mr. H. Coates, Mr. C. V. Crook, Mr. G. Bingley, Mr. R. Welch and Mr. A. K. Coomáraswámy.	0 0 0
To investigate the resistance of road vehicles to traction.	*Chairman*.—Sir Alexander Binnie. *Secretary.*—Prof. H. S. Hele-Shaw. Mr. Aitken, Mr. Aveling, Prof. T. Hudson Beare, Mr. W. W. Beaumont, Mr. J. Brown, Col. R. E. Crompton, Mr. A. Mallock, Sir D. Solomons, Mr. A. Sennett, Mr. E. Shrapnell Smith and Sir J. I. Thornycroft.	90 0 0
Corresponding Societies Committee for the preparation of their report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Dr. Francis Galton, Prof R. Meldola, Mr. T. V. Holmes, Sir John Evans, Mr. J. Hopkinson, Dr. H. R. Mill, Mr. Horace T. Brown, Rev. J. O. Bevan, Prof. W. W. Watts, Rev. T. R. R. Stebbing, Mr. C. H. Read and Dr. Vaughan Cornish.	20 0 0
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1902–1903.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204, George Street, Glasgow. R Barnett Johnstone and R. McLean.	231	None	2s. 6d.	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C.	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath.	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	243	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Belfast Nat. F. C.	Museum, College Square. J. St. J. Phillips and R. Patterson.	330	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Berwicksh. Nat. Club	G. G. Butler, M.A., Ewart Park, Wooler, Northumberland	400	None	10s.	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birmingham and Midland Institute, Paradise Street, Birmingham.	140	None	£1 6s.	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall	186	None	£1 1s.	Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil Soc.	E. A. Pankhurst, 3, Clifton Road, Brighton.	165	10s.	10s.	Report, annually.
Bristol Naturalists' Society, 1862	Bristol Nat. Soc.	S. H. Reynolds, M.A., University College, Bristol.	139	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5, Chapel Street, Peterhead.	170	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	B. L. Oswell, 5, Balmoral Road, Burton-on-Trent.	210	None	5s.	Annual Report. Transactions, occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C.	H. E. Forrest, 37, Castle Street, Shrewsbury.	185	5s.	5s.	Transactions and Record of Bare Facts, annually.
Chester Society of Natural Science, Literature and Art, 1871	Chester Soc. Nat. Sci.	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard.	950	None	5s.	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc.	The Museum, Public Buildings, Penzance. John B. Cornish.	89	None	£1 1s.	Report and Transactions, annually.
Croydon Microscopic and Natural History Club, 1870	Croydon M. N. H. C.	Public Hall, Croydon. G. W. Moore.	230	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C.	Dr. H. C. March, Portesham, Dorchester.	330	None	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885	Dublin N. F. C.	H. J. Seymour, B.A., and W. B. Wright, B.A., 14, Hume Street, Dublin	152	5s.	5s.	*Irish Naturalist*, monthly. Report, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc.	A. Lander, The Medical Hall, Canterbury.	102	None	10s.	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N.H. Soc.	Dr. H. Habgood, Stafford House, Upperton Road, Eastbourne.	100	2s. 6d.	7s. 6d.	Transactions, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1902-1903.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	5, St. Andrew Square, Edinburgh. James Currie, M.A., F.R.S.E.	257	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex.	300	None	15s.	*Essex Naturalist*, quarterly; *Special Memoirs*, occasionally; *Museum Handbooks.*
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. Barclay Murdoch, Capelrig, Newton-Mearns, Glasgow.	250	None	10s.	Transactions, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc. ..	Dr. Freeland Fergus, 207, Bath Street, Glasgow.	1,000	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society, 1874 ..	Halifax S. S.	Literary and Philosophical Society's Rooms, Harrison Road. F. Barker.	100	None	2s. 6d.	*Halifax Naturalist*, every two months
Hampshire Field Club and Archæological Society, 1885	Hants. F. C.	W. Dale, F.G.S., 5, Sussex Place, Southampton.	250	None	7s. 6d.	Proceedings, annually.
Haslemere Microscope and Natural History Society	Haslemere Mic. N. H. Soc.	Rev. G. B. Stallworthy, The Manse, Hindhead, Surrey.	400	None	Minimum, 2s.	Report, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	A. E. Gibbs, F.L.S., St. Albans, and T. E. Lones, M.A., Rokeby Lodge, Watford.	200	10s.	10s.	Transactions, occasionally.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	C. E. Salmon, Clevelands, Reigate, and G. E. Frisby, Fengates Road, Redhill.	87	10s.	10s. and 5s.	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc. .. .	W. S. Parrish, 3, Waltham Street, Hull.	71	None	5s.	Transactions, annually.
Hull Scientific and Field Naturalists' Club, 1886	Hull Sci. F. N. C. ..	T. Sheppard, F.G.S., The Museum, Hull.	184	None	4s.	Transactions, annually.
Institution of Mining Engineers, 1889	Inst. Min. Eng. ..	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.	2,600	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. ..	E. G. Critchley, 23, High Street, Inverness.	190	None	5s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	J. Pim, W. Lawson and C. H. Oldham, 35, Molesworth Street, Dublin.	100	None	£1.	Journal, annually.
Leeds Geological Association, 1873 ..	Leeds Geol. Assoc. ..	Philosophical Hall, Leeds. Walter Parsons.	80	None	5s.	Transactions, occasionally.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	W. M. Rankin, B.Sc., Cockburn Higher Grade School, Leeds.	110	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. Herbert Ellis.	332 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875..	Liverpool E. Soc. ..	R. C. F. Annett, 4, Buckingham Avenue, Sefton Park, Liverpool.	483	None	Resident, £1 1s.; Non-res. and Students, 10s. 6d.	Transactions, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc. ..	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Chapel Street, Liverpool.	730	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions and Report, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1902-1903.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Liverpool Geological Society, 1858 ..	Liverpool Geol. Soc. ..	Royal Institution. H. C. Beasley.	58	None	£1 1s.	Proceedings, annually.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode Cooil-ny-Feeney, Ramsey, Isle of Man.	158	2s. 6d.	Gentlemen, 7s. 6d. Ladies and Non-Residents, 5s.	*Yn Lioar Manninagh*, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester.	800	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly; *Geography*, monthly
Manchester Geological Society, 1838..	Manch. Geol. Soc. ..	5, John Dalton Street, Manchester. W. Saint and J. Tonge, jun.	235	None	£1.	Transactions, monthly.
Manchester Microscopical Society, 1880	Manch. Micr. Soc. ..	E. C. Stump, 16, Herbert Street, Moss Side, and Charles Knight, 193, Oxford Street, Manchester.	185	5s.	6s.	Transactions and Report, annually.
Manchester Statistical Society, 1833..	Manch. Stat. Soc. ..	63, Brown Street, Manchester. F. E. M. Beardsall.	319	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	320	1s. 6d.	3s. and 5s.	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst. ..	Stephenson Memorial Hall. G. Alfred Lewis, Albert Street, Derby.	400	£1 1s.	Members £1 10s. 6d.; Associates and Students, £1	*Transactions of the Institution of Mining Engineers*, monthly
Midland Institute of Mining, Civil and Mechanical Engineers, 1869	Midland Inst. Eng. ..	T. W. H. Mitchell, Mining Offices, Regent Street, Barnsley.	290	None	£1 10s.	*Transactions of the Institution of Mining Engineers*, monthly
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich.	256	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.	1,250	None	£1 5s. and £2 2s.	*Transactions of the Institution of Mining Engineers*, monthly.
North Staffordshire Field Club ..	N. Staff. F. C.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.; W. Wells Bladen, Stone, Staffs.	466	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	Northants. N. H. Soc...	H. N. Dixon, M.A., 23, East Park Parade, Northampton.	180	None	10s.	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of	Northumb. N. H. Soc...	Hancock Museum, Newcastle-upon-Tyne. A. H. Dickinson and Prof. M. C. Potter, M.A.	300	None	£1 1s.	Transactions, annually.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, M.A., University College, Nottingham.	175	2s. 6d.	5s.	Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley.	500		7s. 6d.	Report, annually; Meteorological Obs., occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	380	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, M.Sc., 105, Freehold Street, Rochdale.	245	None	6s.	Transactions, biennially.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1902–1903.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Rochester Naturalists' Club, 1878 ..	Rochester N. C. ..	John Hepworth, Linden House, Rochester.	154	None	5s.	*Rochester Naturalist*, quarterly
Scotland, Mining Institute of, 1878 ..	Mining Inst. Scot. ..	James Barrowman, Staneacre, Hamilton, N.B.	461	None	£2 2s. and £1 5s.	*Transactions of the Institution of Mining Engineers*, monthly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A.N.H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble, Rev. F. W. Weaver and C. Tite.	607	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	G. M. Clark, South African Museum, Cape Town.	207	None	£2	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union ..	George Abbott, M.R.C.S., 33, Upper Grosvenor Road, Tunbridge Wells.	37 Societies	None	Minimum 5s.	*South-Eastern Naturalist*, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng.	Alexander Smith, M Inst.C.E., 3, Newhall Street, Birmingham.	179	£1 1s. and 10s. 6d.	£1 11s. 6d. and £1 1s.	*Transactions of the Institution of Mining Engineers*, monthly.
Toronto, Astronomical Society of, 1884	Toronto Astr. Soc.	Canadian Institute Building. J. R. Collins.	125	None	2 dollars	Transactions, annually.
Tyneside Geographical Society, 1887 ..	Tyneside Geogr. Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,200	None	10s. and 5s.	Journal, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. C. West, 31, Cherry Street, Coventry.	109	2s. 6d.	5s.	Proceedings, annually.
West of Scotland Marine Biological Association of the	W. Scot. Marine Biol. Assoc.	John A. Todd, 190, West George Street, Glasgow.	150	None	Minimum £1 1s.	Report, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore.	240	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield.	185	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, F.L.S., 259, Hyde Park Road, Leeds; F. Hawkesworth, Hunslet, Leeds.	406 and 2,599 Associates	None	10s. 6d.	Transactions, annually; *The Naturalist*, monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst.	420	None	£2	Report, annually.

CATALOGUE OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE CORRESPONDING SOCIETIES DURING THE YEAR ENDING MAY 31ST, 1902.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

BIGG-WITHER, H. "Notes on Detonators." *Trans. Inst. Min. Eng.*, vol. xxi., pages 442-448, 1902.

MIALL, Prof. L. C. "Dew-ponds." *Journal Northants. N. H. Soc.*, vol. xi., pages 18-22, 1901.

THACKER, S. L. (S. Staff. Inst. Eng.). "The Determination of the Calorific Power of Fuel." *Trans. Inst. Min. Eng.*, vol. xxii., pages 75-82, 1901.

WHEELER, ARTHUR O. "Notes on the Field-work of Photographic Surveying as applied in Canada." *Trans. Inst. Min. Eng.*, vol. xxi., pages 418-435, 1901.

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Section B.—CHEMISTRY.

DICKINSON, JOSEPH. "Gravitation of Fire-damp." *Trans. Manch. Geol. Soc.*, vol. xxvii., pages 163-165, 1901.

GLAISTER, Prof. JOHN. "Sewage-disposal and Sewage-purification; a Critical Study of the various Modes now in use from the Points of View of Applicability, Economy and Efficiency." *Proc. Glasgow Phil. Soc.*, vol. xxxii., pages 151-191, 1901.

KITSON, ARTHUR (Midland Inst. Eng.), "The Kitson System of Petroleum Incandescent Light." *Trans. Inst. Min. Eng.*, vol. xxii., pages 52-56, 1902.

MACKIE, Dr. "Why is the Sea Salt?" *Trans. Inverness Sci. Soc.*, vol. v., pages 338-358, 1902.

SMITH, J. KENT (N. Staff. Inst. Eng.). "Water-softening." *Trans. Inst. Min. Eng.*, vol. xxi., pages 278-289, 1901.

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Section C.—GEOLOGY.

BATES, J. I. "Cambrian Rocks of Warwickshire." *Proc. Warw. N. A. F. C.*, 1900, pages 13-20, 1902 (?)

BEASLEY, HENRY C. "Some Recent Exposures of the Keuper Marls at Oxton, Cheshire." *Proc. Liverpool Geol. Soc.*, vol. ix., pages 68-74, 1901.

CADELL, HENRY M. "The Oilshale-fields of the Lothians." *Trans. Inst. Min. Eng.*, vol. xxii., pages 314-371, 1902.

— The Carboniferous Limestone Coal-fields of West Lothian." *Trans. Inst. Min. Eng.*, vol. xxii., pages 372-400, 1902.

CADMAN, JOHN (N. Staff. Inst. Eng.). "The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." *Trans. Inst. Min. Eng.*, vol. xxii., pages 89-99, 1901.

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* Titles of Papers on other Subjects than Mining or Mechanical Engineering have not been reprinted.

CALLAWAY, Dr. C. "A Sketch of the Archæan Geology of Anglesey." *Proc. Liverpool Geol. Soc.*, vol. ix., pages 82-93, 1901.

COATES, HENRY. "The Progress of Geology during the Nineteenth Century." (Annual Address.) *Proc. Perths. Soc. Nat. Sci.*, vol. iii., pages lxxix.-xciv., 1901.

DAVID, W. "The Position of and Method of Working Bath Stone in the Quarries of the Bath Stone Firms." *Trans. Inst. Min. Eng.*, vol. xx., pages 495-499, 1902.

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RAYNER, FRANK, and J. HAROLD HERBERT. "The Scenery and Underground Waters of the Malham District (West Yorkshire)." *Trans. Nott. Nat. Soc.*, 1900-1901, pages 34-40, 1901.

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SANDEMAN, J. J. "Gold-mining in the Rossland District, British Columbia." *Trans. Inst. Min. Eng.*, vol xx., pages 401-403, 1901.

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Section D.—ZOOLOGY.

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Section E.—GEOGRAPHY.

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Section F.—ECONOMIC SCIENCE AND STATISTICS.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word ; and in the case of Names, it includes both the Christian Name and the Surname ; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

The following contractions are used :—

M.—Midland Institute of Mining, Civil and Mechanical Engineers.

M.C.—The Midland Counties Institution of Engineers.

S.—Mining Institute of Scotland.

N.E.—North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.